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DESIGN OF AN ARTILLERY TOWING LIGHTWEIGHT AUXILIARY SYSTEM (ATLAS)

H.G. Kirchner

MAY 1974

Final Report

U.S. ARMY ARMAMENT COMMAND

PREPARED BY

PACIFIC CAR AND FOUNDRY COMPANY
RENTON, WASHINGTON

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Prepared for

ARTILLERY & ARMORED WEAPONS SYSTEMS DIRECTORATE

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ARTILLERY MOBILITY DEVICE
PROPULSION DEVICE
AUXILIARY PROPULSION
POWER ASSIST
DESIGN ANALYSIS

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

THIS TECHNICAL REPORT SUMMARIZES THE CONTRACTOR'S DESIGN AND ANALYSIS EFFORT ON A CONCEPT TITLED ARTILLERY TOWING LIGHTWEIGHT AUXILIARY SYSTEM (ATLAS). THE ATLAS CONCEPT WILL PROVIDE IMPROVED MOBILITY AND AUXILIARY POWER FOR TOWED ARTILLERY WEAPONS IN REMOTE BATTLEFIELD AREAS. SPECIFICATIONS AND DETAILED CALCULATIONS ARE PRESENTED FOR ALL MAJOR COMPONENTS SUCH AS THE POWER TRAIN, THE SUSPENSION, THE AUXILIARY POWER SYSTEMS, ETC. THIS HELICOPTER TRANSPORTABLE PROPULSION DEVICE WILL SIGNIFICANTLY ENHANCE THE EFFECTIVENESS OF TOWED ARTILLERY WEAPONS.

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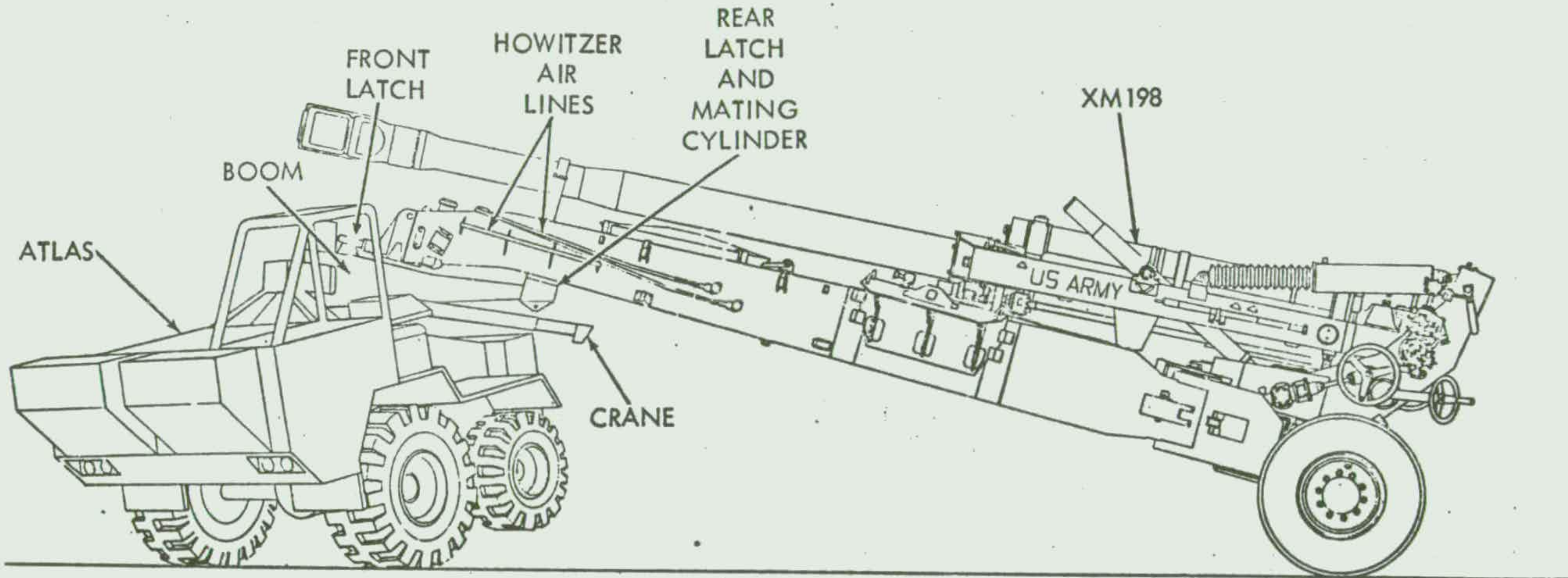
TABLE OF CONTENTS

	Page
INTRODUCTION	1
SPECIFICATIONS	1
DESIGN DISCUSSION	5
Vendor Information	10
Sketches	11
TECHNICAL DATA AND CALCULATIONS	16
Frame	17
Powertrain	54
Suspension	126
Hydraulic	179
Air	188
Brakes	200
Miscellaneous	215
LIST OF DRAWINGS	235


FRONT LATCH
HOWITZER AIR LINES
REAR LATCH AND MATING CYLINDER
XM198
BOOM
ATLAS
US ARMY
CRANE

ATLAS

Technical Report

Introduction

ATLAS, an Artillery Towing Lightweight Auxilliary System is primarily a highly maneuverable tractor designed for transport and support of the XM198 155mm Howitzer. It is lightweight, helicopter transportable, and in addition is capable of supplying auxilliary power, electrical, compressed air and hydraulic to support associated equipment. In support of the howitzer it can carry 30 rounds each of projectiles, mixed zone powder charges and up to 64 varied types of fuzes. It is a front wheel drive, rear wheel steer tractor and when hooked to the howitzer can pivot steer about the center of its drive axle, enabling it to traverse the howitzer while it sits on its own base plate. It is also capable of cross-country operation and has fording capability, and is powered by a dependable, derated diesel engine using primarily dependable commerical powertrain components.

Specifications

Powertrain

Engine - Detroit Diesel Allison 4-53N40, water cooled

116 horsepower @ 2,800 rpm

252 lb-ft torque @ 1,500 rpm

212 In^3 displacement

Clutch - 12" RT, Rockford clutch

Transmission - Clark Equipment Company Model 280V

5 speed manual - remote shift

Transfer Case - Pacific Car and Foundry Company Special Design

2 speed, 1.08: 1 and 1.985: 1, with/disc

Parking brake

Drive Axle - Rockwell Standard, H-140, modified with/offset bowl,

limited slip differential, 8.2: 1 ratio, disc brakes

Suspension

Drive Axle - trailing arm, torsion bar, tubular shock absorbers,

6" jounce, 6" rebound

Steering Axle - Trailing arm, coil spring, tubular shock absorbers,

4.25 " jounce, 4.75" rebound

Tires - Drive axle, 16.5 - 19.5 wide profile Load range H (16 ply rating)

inflation 60 psi

Steer axle, 12-16.5 wide profile, load

Range D (8 ply rating) inflation 30 psi

Wheel base - 45.5" (solo), 252" (with/howitzer)

Steering (Power)

Solo operation, hydraulic cylinders on axle

Towing howitzer, hydraulic rotary actuator acting through King pin on boom

Minimum turning radius, solo, 146" wall-wall

Performance

Maximum drawbar pull - 13,500 pounds

Maximum speed 38 mph with/howitzer, 20 mph solo

Gradeability - 50% ascending, 60% descending (with/howitzer)

Side slope - 40% (with/howitzer)

Fording depth - 48 inches

Cross-country speed - in excess of 5 mph

Ammunition stowage

30 rounds projectiles, 155mm

30 rounds powder charges, mixed zones

64 fuzes, M557 and/or M514

Auxilliary Systems

Electrical - 24 VDC, 200 amp alternator

2 type 6TN batteries

Compressed Air - 100 psi maximum, 2240 In^3 reservoir capacity,

12 CFM compressor

Hydraulic - 2,000 psi maximum, 23 GPM, open center

Crane - Hydraulic - Electric, 2,000 pound maximum lift

9 foot maximum reach (manual telescoping)

Winch - 10,000 pound planetary, 2 speed

Overall Dimensions

Length	110 Inch (less front and rear ammo racks)
Width	96 Inch
Height	109 Inch (reducible to 94 inch)
Weight	8,000 pound (less ammo)

DESIGN DISCUSSION

1. Frame

Since the completion of the final weight analysis is apparent that additional consideration needs be given to whether the frame is indeed over designed and if its weight could be reduced. In the case of the boom, cross beam, and side frames this is likely and also the frame itself. If new analysis is undertaken use should be made of one of the more simple commerically available computer analysis programs such as ANSYS, Engineering Analysis System from Swanson Analysis Systems Inc. Some additional shop drawings will need to be made when the test rig is built. The engine covers were never layed out but a concept sketch is included at the end of this section. Lifting eyes and towing eyes have not been incorporated. However it is apparent that the strong front and rear corners of the sub-frame provide suitable points for attachment of these eyes.

2. Powertrain

Detroit Diesel Allison should be contacted and consulted on problems to be encountered in fording and the engine oil pan, oil pump strainer bracket and pickup tube need to be modified to accommodate the 9° nose down or up engine attitude (depending on whether operating solo or with/howitzer) on extreme slopes. No detail drawings were made for the idler (pulley, arm, etc.) the alternator pulley, mounting bracket and brace or for the air compressor spacer. The exhaust piping is well defined but needs shop drawings.

The oil seal between the transmission and transfer case may not be effective in separating the oil in the two cases. It is suggested that a double lip tandem seal be installed in place of the single lip seal shown as in the sketch at the end of this section.

A conflict occurred in regard to the driveshaft in that the Mechanics Universal CV (constant velocity) universal joint doesn't fit the standard yokes. This wasn't discovered until too late, however, when Mechanics Universal was contacted by phone they assured us that they had the necessary yokes in production to fit the CV joints. Any information on this will be passed on.

3. Suspension

The H-140 axle may need to be reinforced, mainly because of the additional deflection of the axle housing from offsetting the differential. This deflection will create an end moment on the splined end of the axle shaft and will cause additional wear on the splines and possibly lead to fatigue failure of the axle shaft. Clarification is forthcoming from Rockwell Standard on this. If there is no definite danger of fatigue failure in the axle shaft, it is recommended that the reinforcing be omitted for the test rig in the interest of saving weight and cost. (See Axle Housing Stress Analysis).

The shock absorbers are a special design, depending on the length of stroke and this wasn't a long lead item so it was left to be completed concurrently with the test rig fabrication.

The suspension arms on the steer axle are somewhat unconventionly designed in that they must deflect sideways and twist as well as support a vertical bending moment when the axle tips. There is also an axial load imposed if the vehicle is braked. When the vehicle is traveling forward the axial load is a tensile load and as such doesn't cause great concern. The crucial loading would come from braking when backing up or backing into something especially if the axle is at full tip as well.

This distortion of the suspension arm is what provides roll resistance to the entire suspension. If the ends of the arms are not held fixed then an additional roll stabilizer bar must be added. (One may be needed even with the present suspension arms. The roll stiffness desired is not a hard and fast number).

As noted on the suspension installation, and in the calculations, a better procedure would be to mount the arm or rubber connections so that approximately 75% of the horizontal deflection and twist are taken up in the rubber. The suspension arm has been redesigned for this and thickened to .50 thick.

If the above approach is still suspected or if a roll stabilizer bar is still needed, then the suspension must be modeled after the drive axle suspension, although only a single arm need be used. It will require a heavy roll stabilizer and will increase the vehicle weight.

4. Hydraulic and Air Systems

No piping layouts were attempted because of lack of overall vehicle definition at the time they would have had to be initiated. At any rate, the usual test rig practice is to create the piping drawings after the piping is installed in the test rig. All the large hydraulic and air components were located in the vehicle however (see 8019-502). Note should be taken of the Safety Evaluation comments on additional safety that could be built into the steering circuits.

5. Electrical System

For the same reasons as for the hydraulic and air systems, only an electrical schematic was created. One oversite was the provision for mounting the batteries. Space was reserved for them above the transfer case and transmission however, and the rear frame number and upper cross member provide handy mounting supports. The batteries should be mounted in a tray, parrallel to the engine crankshaft centerline as shown in the sketch at the end of this section.

6. Controls and Driver's Compartment

Several shop drawings will be needed for such things as the instrument panel, clutch pedal, light brackets, etc. The control cable lengths will have to be determined by trial installation on the test rig (this can be done with stiff 3 conductor electrical wire). Shop drawings will be needed for the roll cage also.

7. Crane and Winch

The design of the crane is incomplete in the area of the base and hinge for the boom. The informational drawings on details of the boom base, on the mounting of the overload limiter and details of standard swing brakes for the BA-2 Workhorse were not received from the Autocrane Company. The information will, however, be passed on when and if it is received.

The submersion capability for the two speed winch requires only the addition of a double lip seal to the shifting spool. If the two speed capability is forgone, a single speed locked in low gear winch has been produced for the Engineer Corps, Ribbon Bridge (USAMERDC) and the winch can be reversed and held in neutral hydraulically without any change in the hydraulic system.

8. Stowage

No racks for the 9 powder charges on the front of the vehicle or for the 16 projectiles on the rear of the vehicle have been designed. (See sketch at end of this section). Also details of the straps and rachet tighteners were not worked out. The scheme was to strap down the powder charges and projectiles in groups of 3 or 4 using nylon straps anchored with footman's loops and tensioned with ratchet fasteners.

Additional stowage needs to be considered, such as 5LB CO_2 fire extinguisher, operators rifle, tools, tire inflater gage and hose, etc.

9. General

Detailing of minor (and of most) brackets was ignored in order to concentrate on the other major areas. These are most often more ingeniously designed as the vehicle is being built.

VENDOR INFORMATION

AXLE, DRIVE

Rockwell Standard Division
Rockwell International
1055 West Maple Road
Clawson, Michigan 48017
Mr. Fred M. Cole Jr.
Military Products Engineer

AXLE, STEER

Hadco Engineering
2000 Canfield Avenue
Los Angeles, California 90040
Mr. Mike Guarino

BRAKES, DRIVE AXLE AND PARKING

B. F. Goodrich Company
Troy, Ohio 45373
Mr. Joe Moore
PCF contact was through Zink Enterprises, P.O. Box 771
Bellevue, Washington 98004
Mr. Bill Zink

BRAKES, STEER AXLE

Tol-O-Matic
246 Tenth Avenue South
Minneapolis, Minnesota 55415
Mr. William C. Branham
Marketing Manager

ENGINE

Detroit Diesel Allison
Division of General Motors
13400 West Outer Drive
Detroit, Michigan 48228
Mr. Ron Lund
Engineering Department

TRANSMISSION

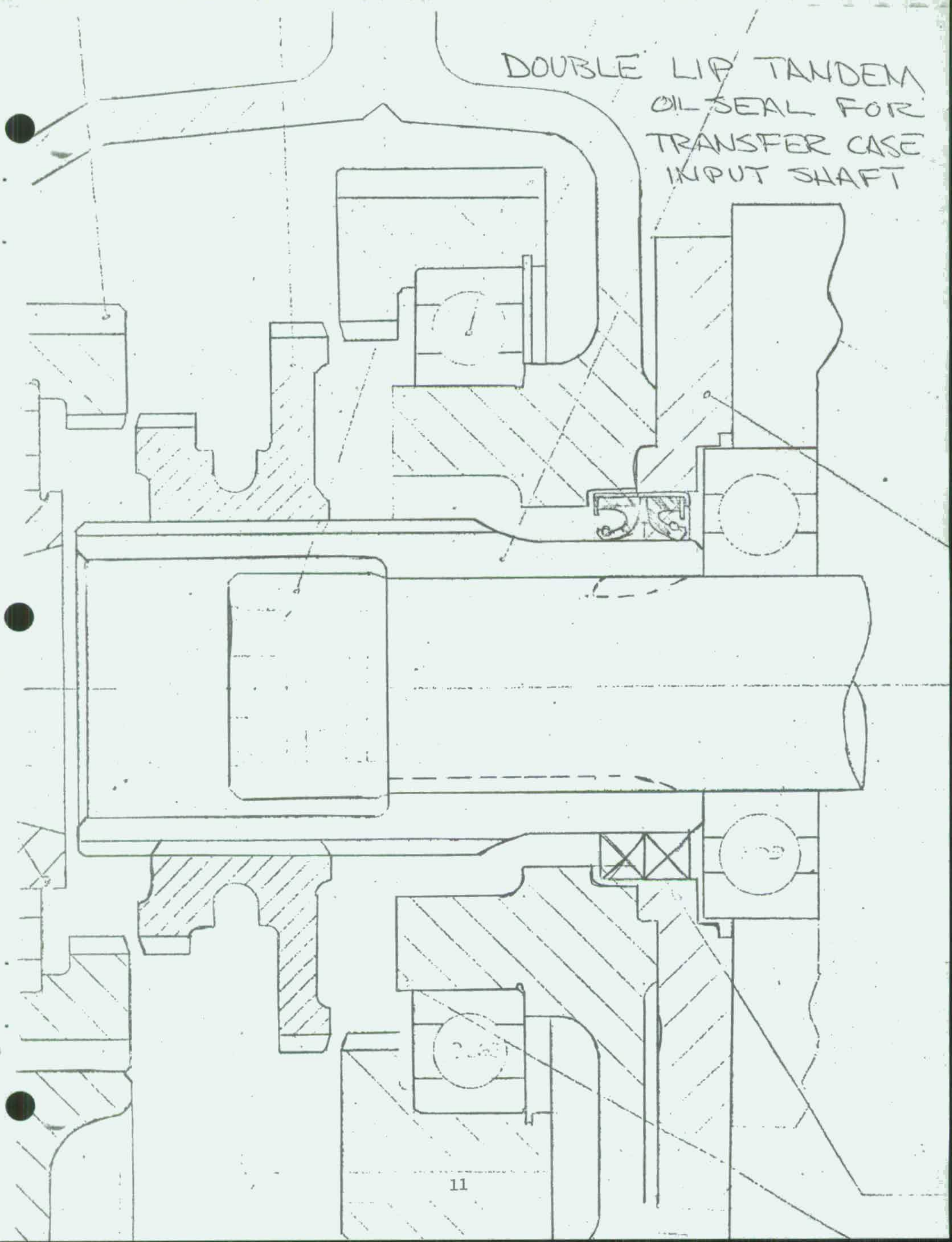
Clark Equipment Company
Western Sales Office
1902 SeMorrison Street
Portland, Oregon 97214
Mr. W. A. VanLannen, Manager

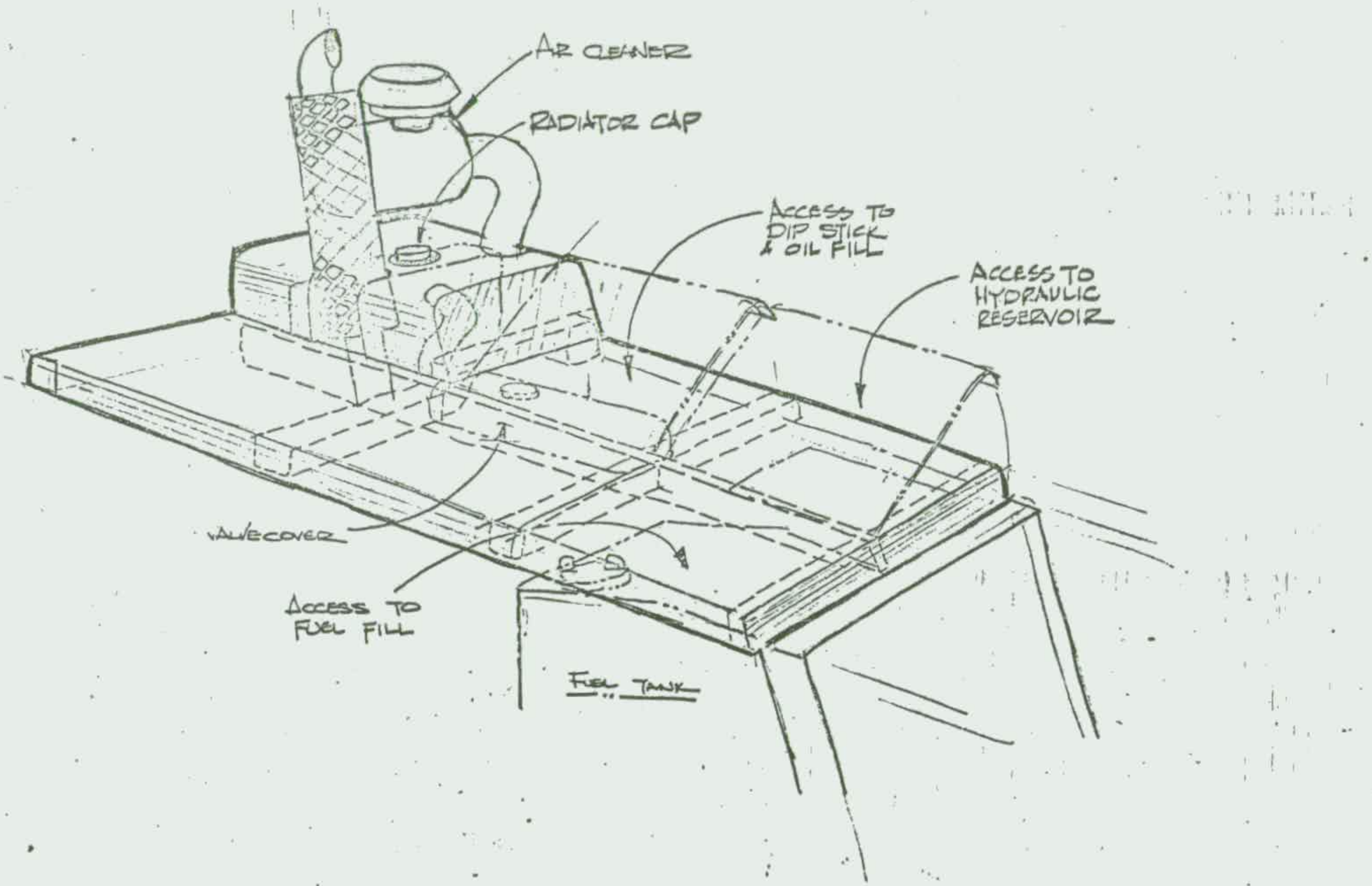
SHOCK ABSORBERS

Gabriel of Canada
22371 Newman Avenue
Dearborn, Michigan 48124
Mr. Ral F. Homovic, General Sales Manager

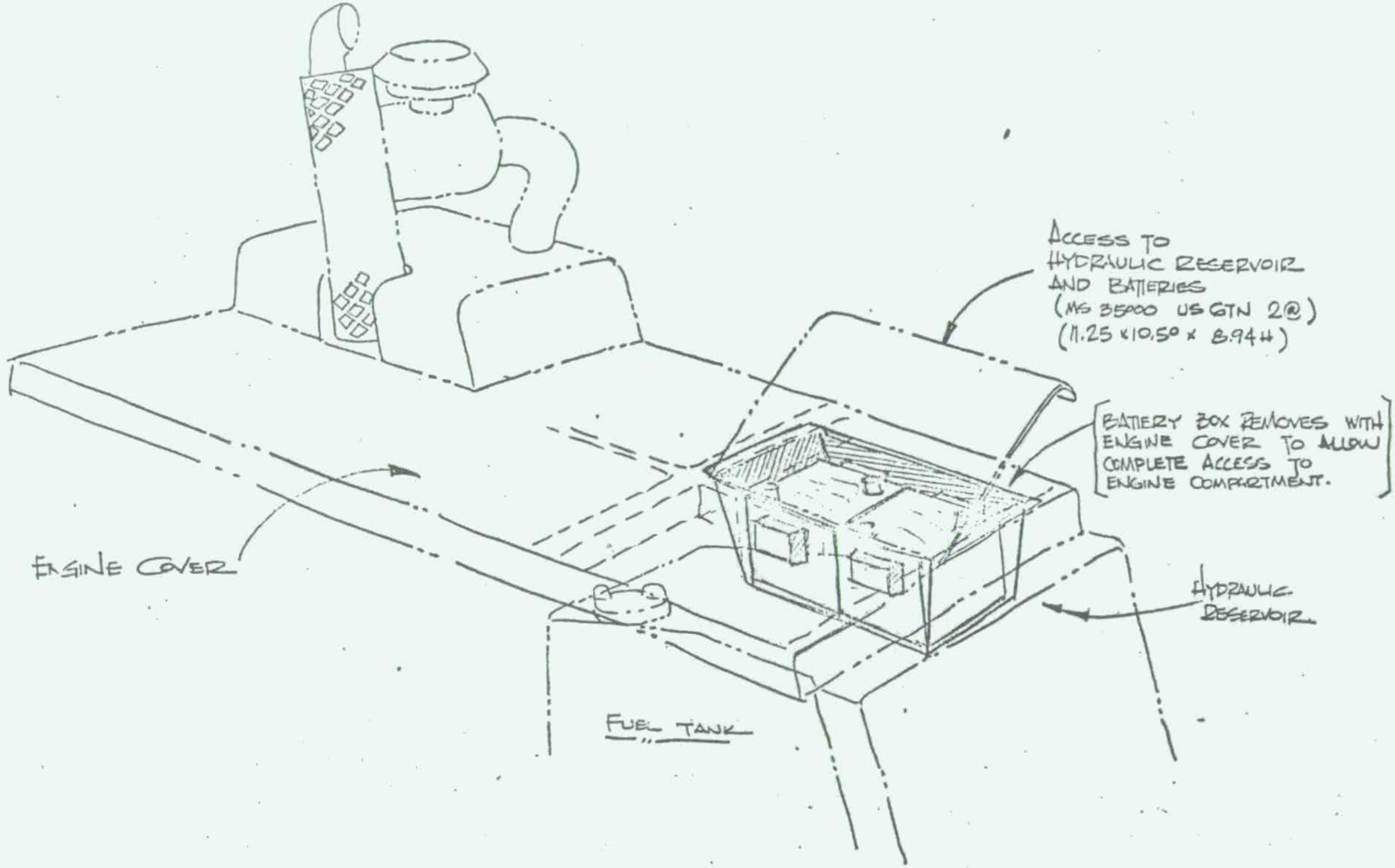
CRANE

Auto Crane Company
9260 Broken Arrow Expressway
Tulsa, Oklahoma 74145
Mr. Jack Hamilton

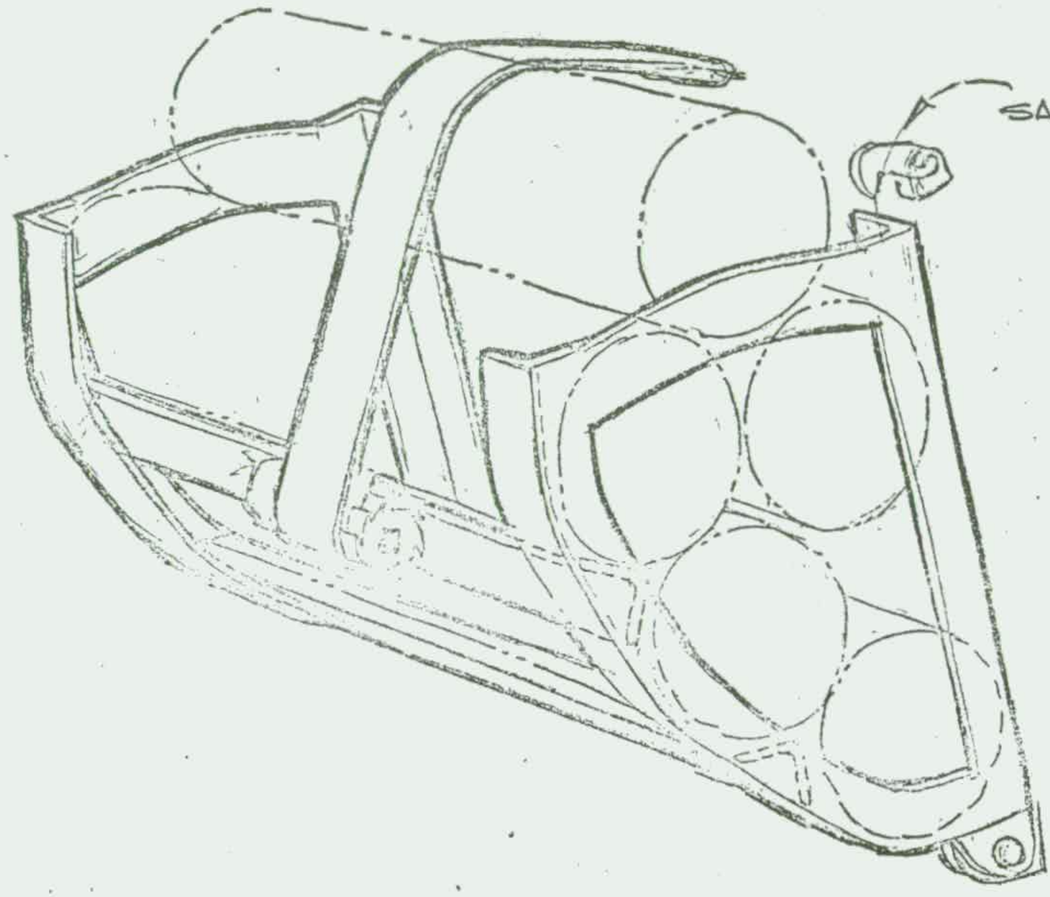

DOUBLE LIP TANDEM
OIL SEAL FOR
TRANSFER CASE
INPUT SHAFT



ENGINE COVER

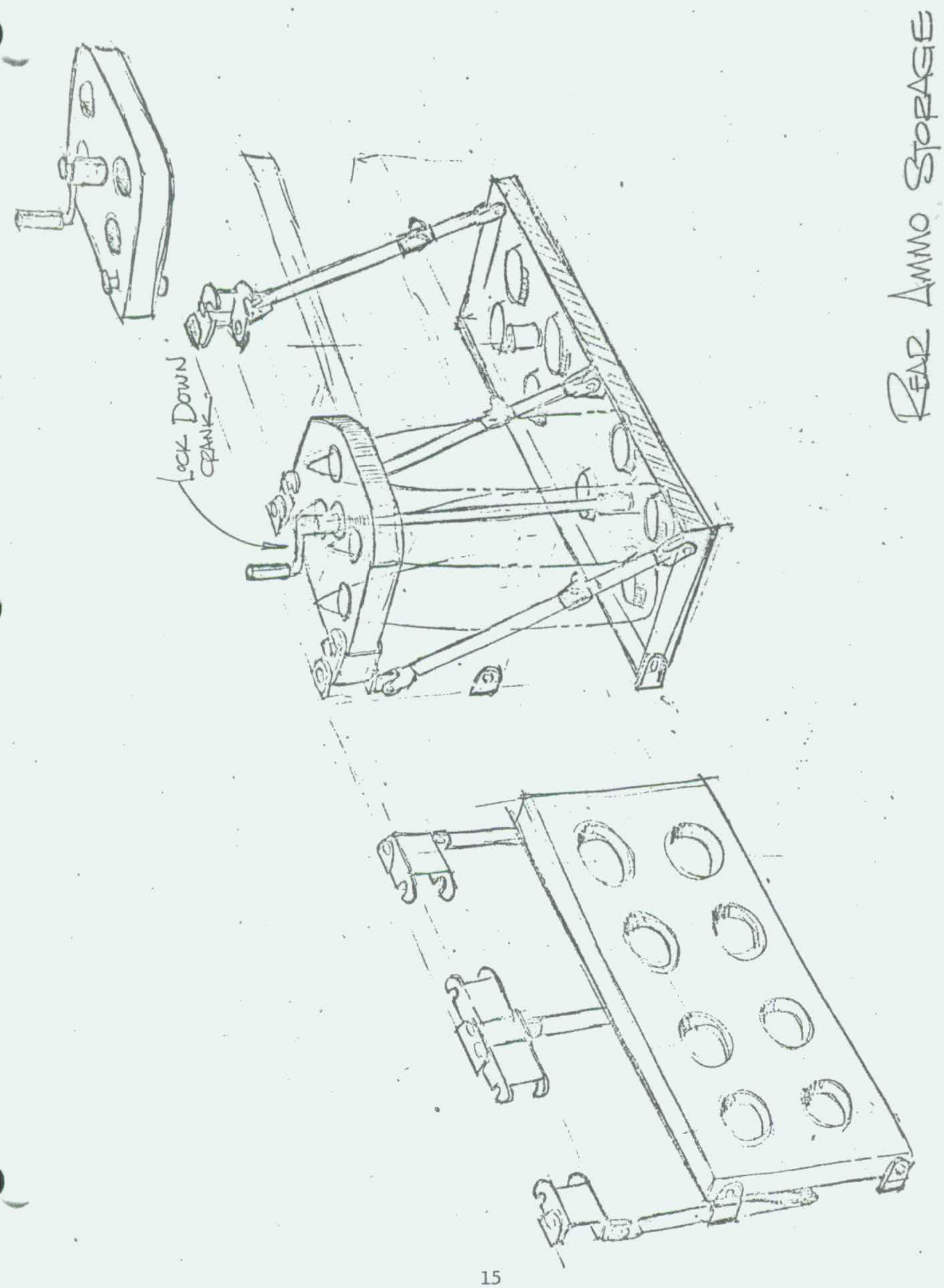

ACCESS TO
HYDRAULIC RESERVOIR
AND BATTERIES
(MS 35000 US GTN 2@)
(11.25 x 10.50 x 8.94 H)
BATTERY BOX REMOVES WITH
ENGINE COVER TO ALLOW
COMPLETE ACCESS TO
ENGINE COMPARTMENT.
ENGINE COVER
HYDRAULIC
RESERVOIR
FUEL TANK

BATTERY BOX



FRONT POWDER CHARGE RACK

2 REQD 31 JAN 74 RSH


REAR AMMO STORAGE
31 JAN 74
LOCK DOWN CRANK

TECHNICAL DATA AND CALCULATIONS

1. Frame
2. Powertrain
3. Suspension
4. Hydraulic
5. Air
6. Brakes
7. Miscellaneous

    Electrical Schematic

    Final Weight C.G. Analysis

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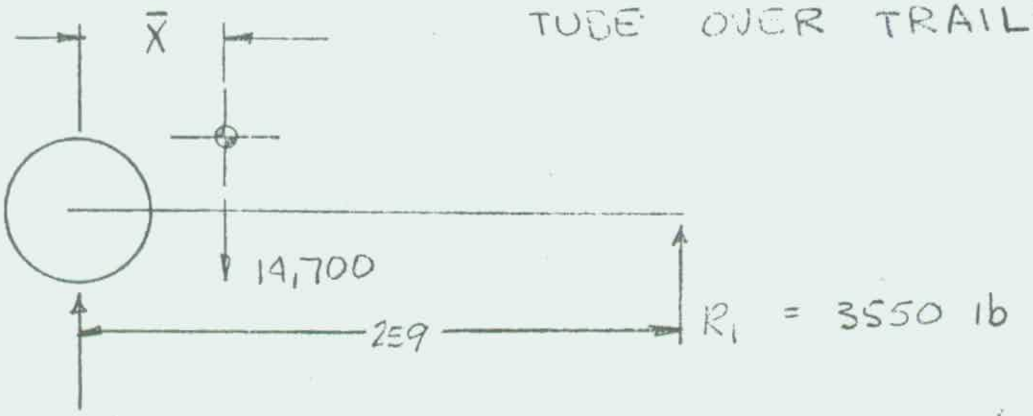
HOWITZER HORIZONTAL C.G. LOCATION WITH TUBE OVER TRAILS:



$$R_2 = 14{,}700 - 3550 = 11{,}150 \text{ lb}$$

$$\bar{X} = \frac{259\,(3550)}{14{,}700} = \underline{\underline{62.5 \text{ INCHES}}}$$

WHEN THE LUNETTE IS 84.0 INCHES ABOVE THE GROUND LINE, THE DISTANCE TO THE C.G. CHANGES TO 55 INCHES.

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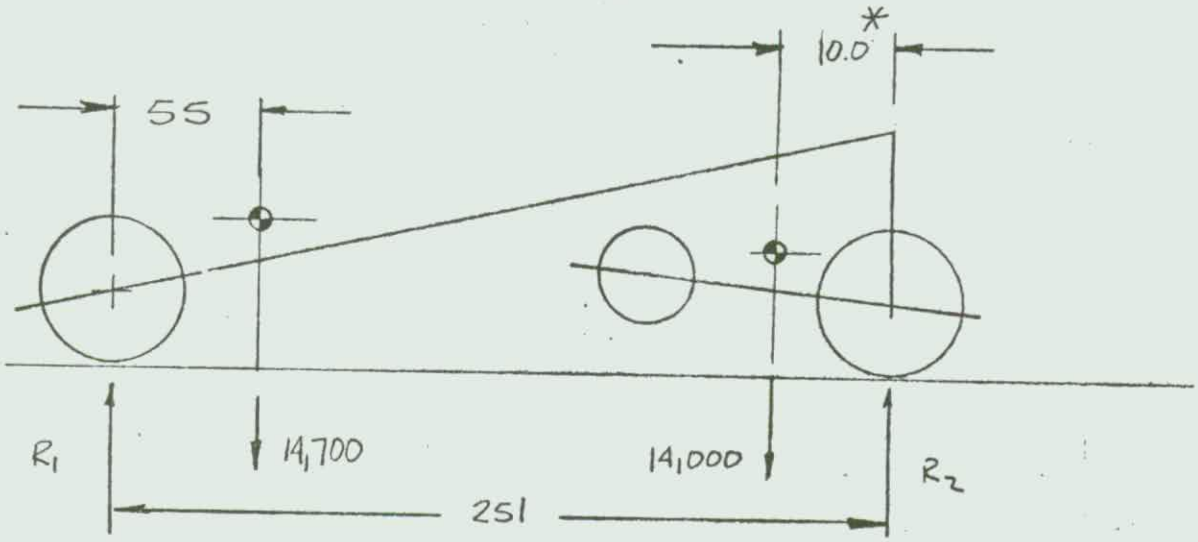

$$R_2 = \frac{14{,}700(55) + 14{,}000(241)}{251} = 16{,}663 \text{ lb}$$

$$R_1 = 12{,}037 \text{ lb}$$

* NOTE: THE C.G. OF THE ATLAS CHANGES FROM 16.0 FROM THE AXLE TO 10.0 FROM THE AXLE WHEN IT IS IN THE RAISED POSITION (TILTED ~15°).

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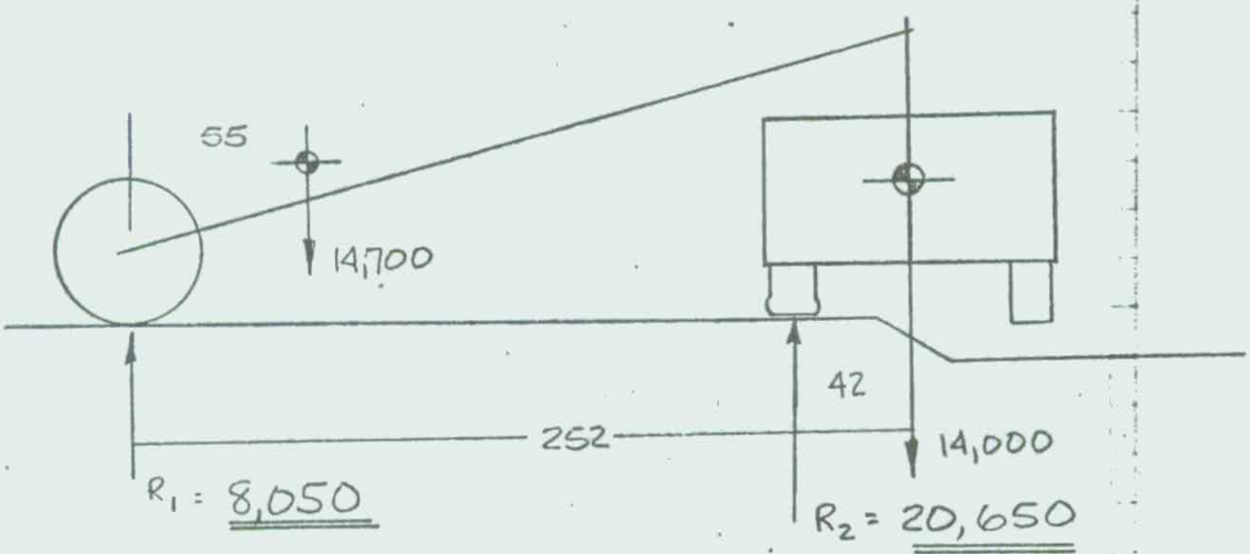
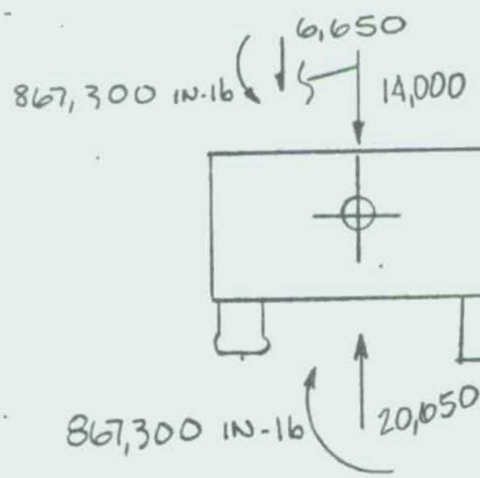


$$\Sigma M_{R_1} = 0$$

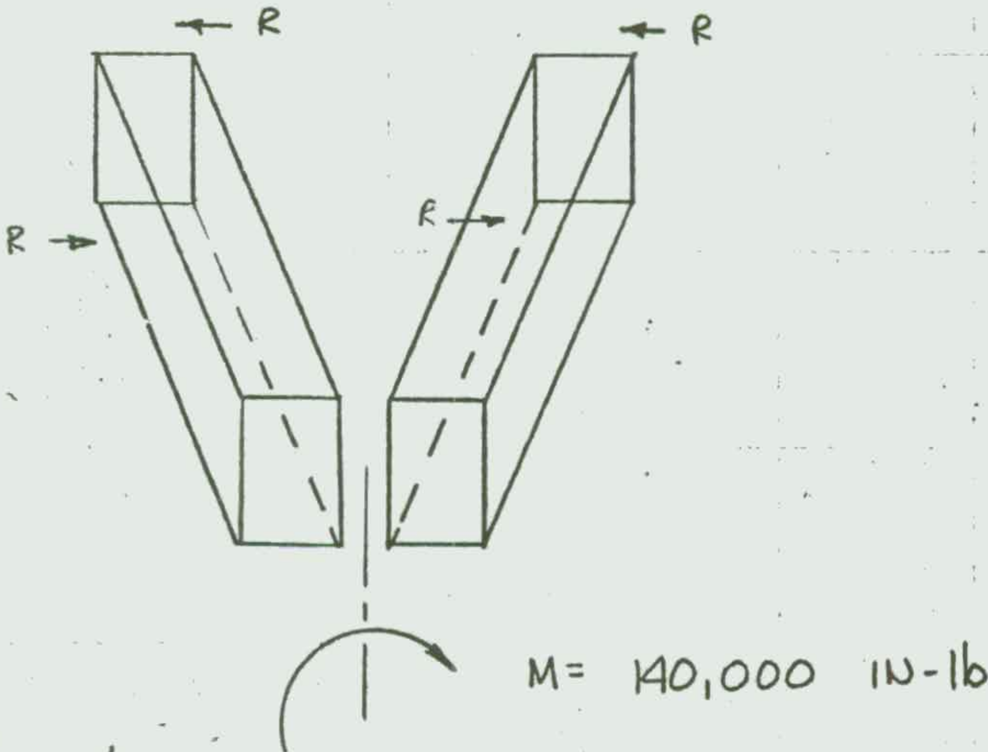
$$\therefore\ (55)(14{,}700) + (252)(14{,}000) - .210(R_2) = 0$$

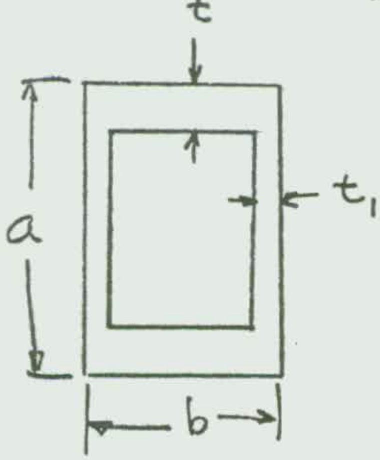
$R_2 = 20{,}650$ $\qquad$ $R_2 = 8{,}050$

VEHICLE
FREEBODY:
(AT PIN)



FIND THE ANGULAR DEFLECTION OF THE HOWITZER TRAILS WHEN THE ATLAS IS 90° TO THE TRAILS





$$\theta = \frac{TL}{KG}$$

$$K = \frac{2tt_1\,(a-t)^2(b-t_1)^2}{at + bt_1 - t^2 - t_1^2}$$

FOR THE HOWITZER TRAILS ASSUME:

$a = 16.0$ (ave) (12.75 to 22)
$b = 10.0$
$t = .50$
$t_1 = .25$

$T = 70{,}000$ IN-lb

$L = 175$ IN

$G = 3.8 \times 10^6$

$$K = \frac{(2)(.50)(.25)(16.0-.5)^2(10.0-.25)^2}{(16)(.5) + 10(.25) - .5^2 - .25^2}$$

$$K = \frac{.25(15.5)^2(9.75)^2}{8 + 2.5 - .25 - .06}$$ 10.19

$K = 560$

$$\theta = \frac{(70{,}000)(175)}{560(3{,}800{,}000)} = .0057 \text{ RADIANS}$$

$.0057(57.29) = .32^\circ$

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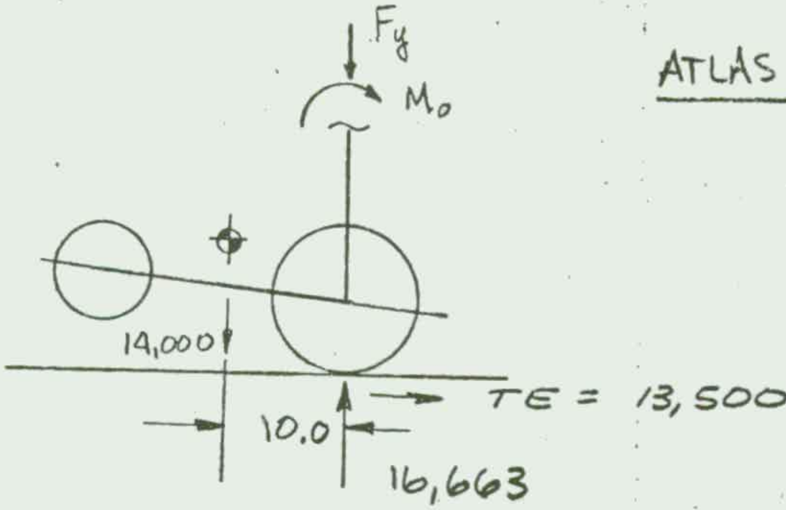
ATLAS FREEBODY



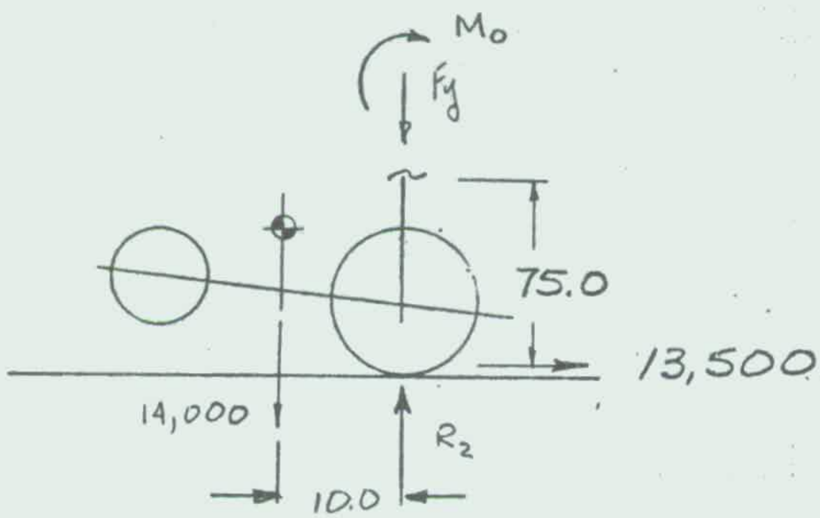
$M_o = 14{,}000\,(10) = 140{,}000$ lb-in

$F_y = 16{,}663 - 14{,}000 = 2{,}663$ lb

TO DETERMINE THE STRESS IN THE FRAME, HINGE, AND HOWITZER TRAILS, IT WILL BE ASSUMED THAT THE TRACTIVE EFFORT IS 13,500.

PCF-RN-597

FOR THE WORST CASE ASSUME THAT THE ATLAS DEVELOPS MAXIMUM TRACTIVE EFFORT TO MOVE THE HOWITZER:



$F_y = 2,663$ lb

$M_o = 14,000\,(10.0) + (13,500)(75) = \underline{\underline{1,152,500 \text{ in-lb}}}$

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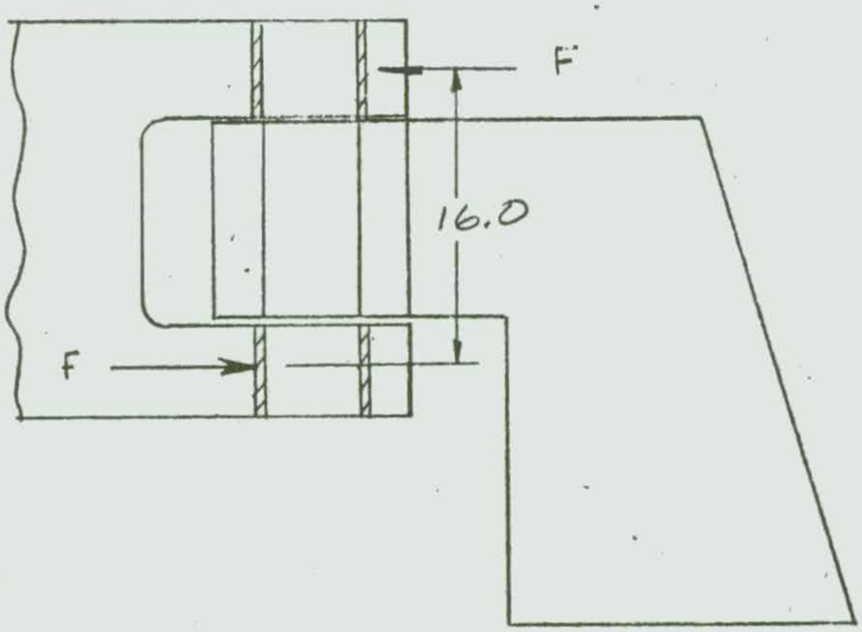


"DU" BUSHING LOAD = $M_o/16$

LOAD = 92,200 lb

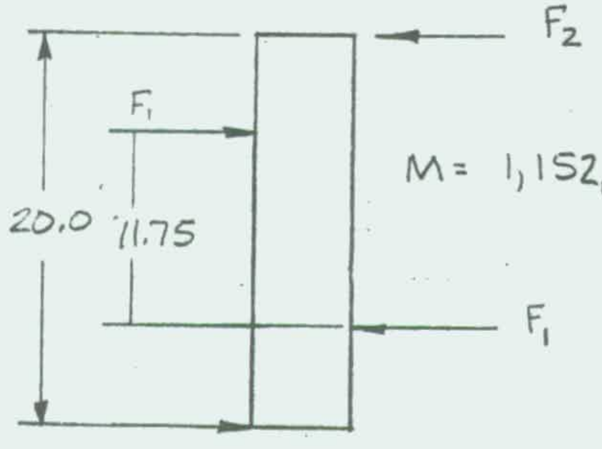
FOR (64DU60) 4.0 ID × 3.75 LONG:

PROJECTED AREA = 15.0 IN^2

STRESS = 92,200 / 15 = $\underline{\underline{6,150 \text{ lb}/\text{IN}^2}}$

CONSIDERING NO LOAD DISTRIBUTION TO FIND PIN STRESS:

DIA = 4.0 IN
AREA = 12.56 IN^2
"I" = 12.6 IN^4

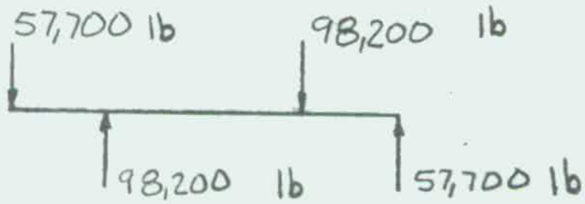


M = 1,152,500 IN-lb (APPLIED BY F_1)

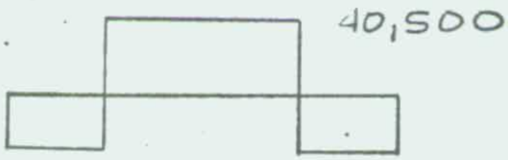
F_1 = 1,152,500 / 11.75 = 98,200 lb

F_2 = 1,152,500 / 20 = 57,700 lb

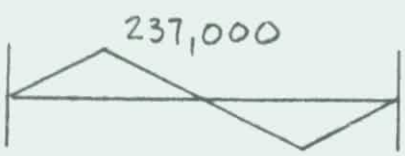
LOAD



SHEAR



MOMENT



BENDING STRESSES:

$$\sigma = \frac{My}{I} = \frac{(237{,}000)(2)}{12.6} = 37{,}600 \text{ lb/in}^2$$

SHEAR STRESS:

$$\tau = F/A = 40{,}500/12.56$$

$$\tau = 3{,}230 \text{ lb/in}^2$$

PRINCIPAL STRESS:

$$\sigma_1 = \frac{37{,}600}{2} + \left[\left(\frac{37{,}600}{2}\right)^2 + (3{,}230)^2\right]^{\frac{1}{2}}$$

$\sigma_1 = 37{,}875 \text{ lb/in}^2 \longleftarrow$ MAXIMUM PRINCIPAL

$$\tau_{MAX} = \pm\left[\left(\frac{37{,}600}{2}\right)^2 + (3{,}230)^2\right]^{\frac{1}{2}}$$

$\tau_{MAX} = 19{,}075 \text{ lb/in}^2 \longleftarrow$ MAXIMUM SHEAR

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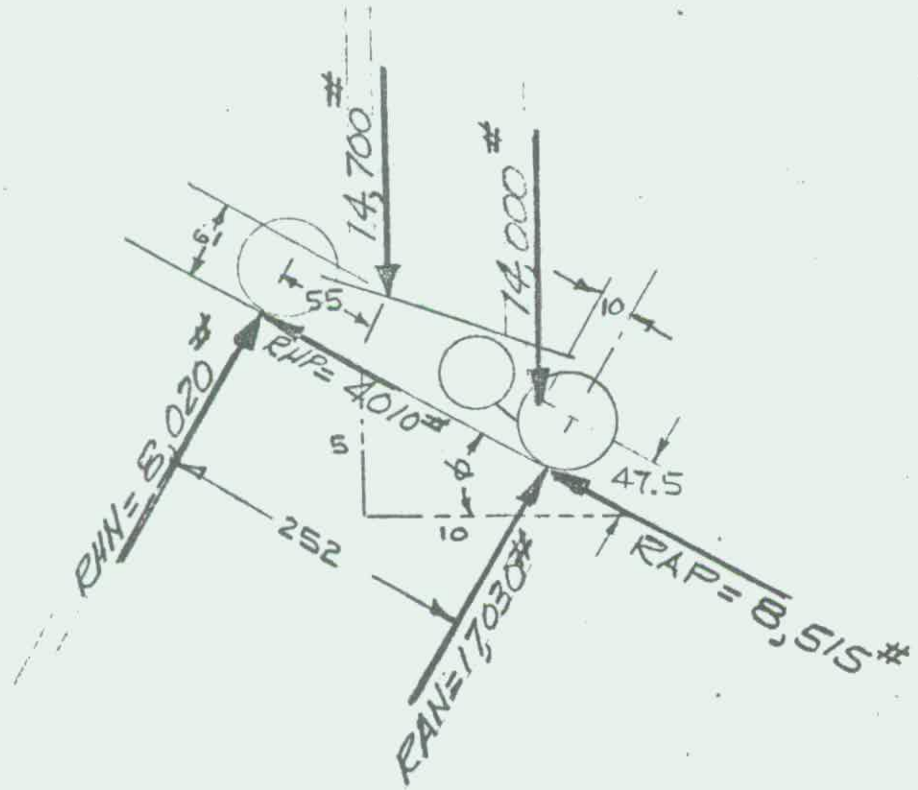
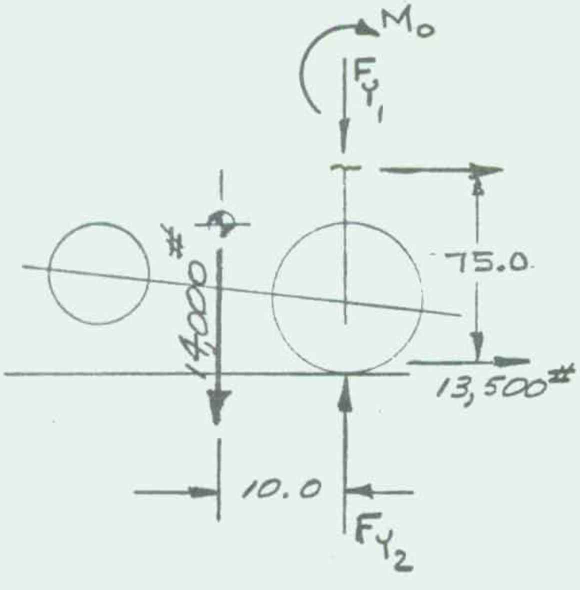
EVALUATION FOR "KING PIN" WELDED TUBE STRUCTURE



REQUIRED DROP BAR PULL = 13,500#



$M_o = (14{,}000^{\#})(10\,in) + (13{,}500^{\#})(75\,in)$

$M_o = 140{,}000$ in-lb $+ 1{,}012{,}500$ in-lb

$\boxed{M_o = 1{,}152{,}500 \text{ in-lb}}$

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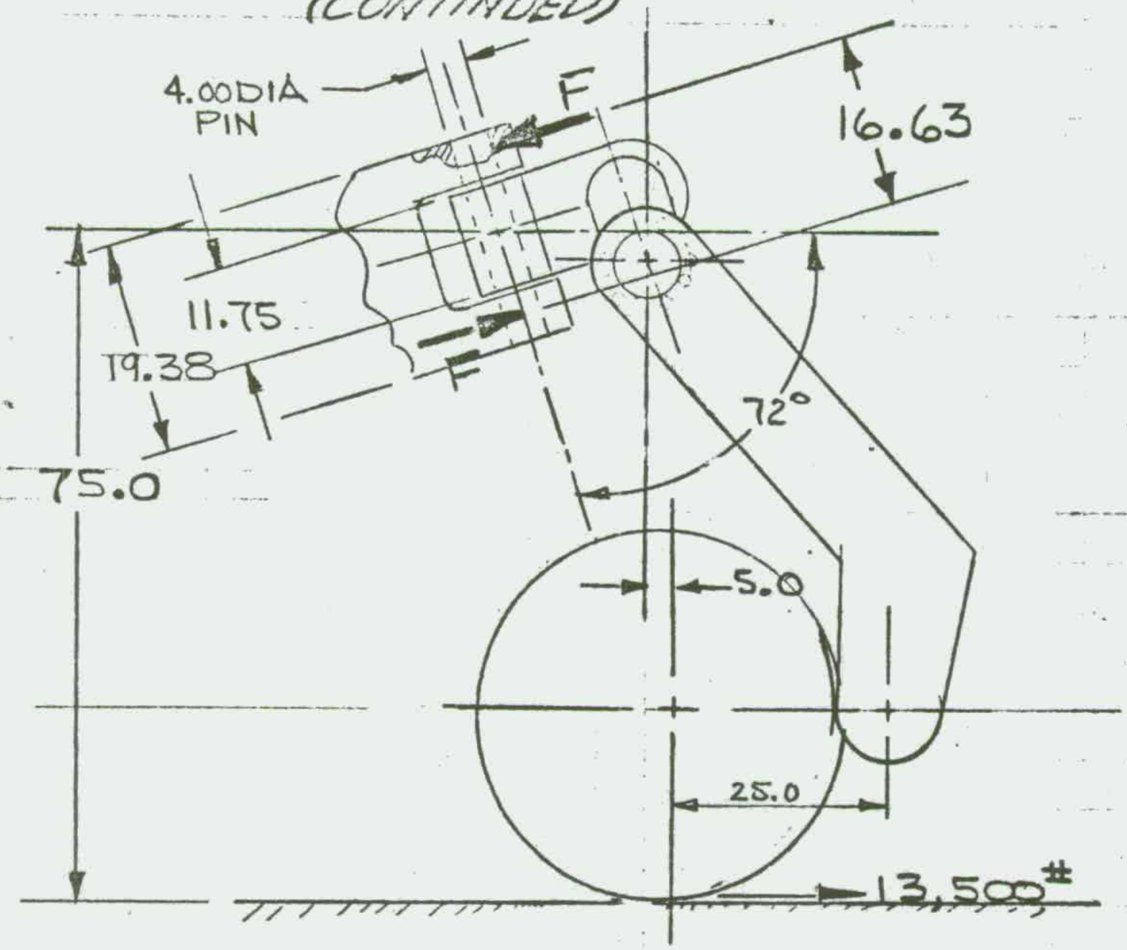
REPORT NO.

EVALUATION FOR "KING PIN" WELDED TUBE STRUCTURE (CONTINUED)



$$F = \frac{1,152,500 \cancel{\text{IN}}\text{-Lb}}{16.63 \cancel{\text{IN}}}$$

$$F = 69,303 \text{ Lb}$$

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ENGINEERING DEPARTMENT

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CHECKED BY

DATE

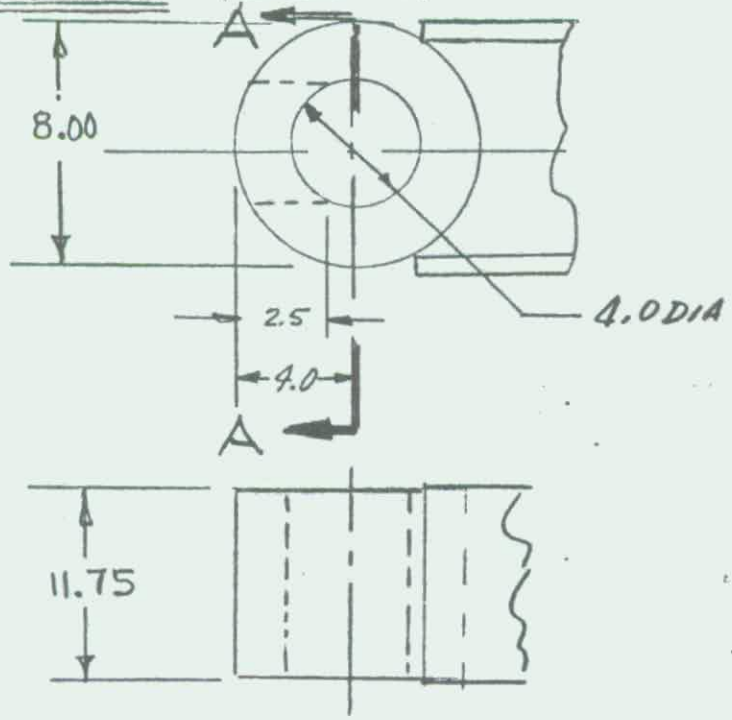
ORDER NO.

PAGE OF

REPORT NO.

EVALUATION FOR "KING PIN" WELDED TUBE STRUCTURE (CONTINUED)

BAR EVALUATION (ITEM #1)



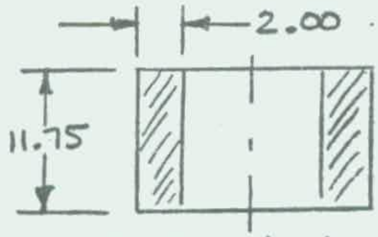
SHEAR TEAROUT:

$$S_s = \frac{F}{A}$$

$$S_s = \frac{69,303 \text{ Lb}}{(2)(2.5)(8.00)} = \frac{69,303 \text{ Lb}}{40.0 \text{ IN}^2}$$

$$\boxed{S_s = 1,733 \text{ PSI}}$$

TENSION:



SECTION A-A

$\text{AREA} = (2.00)(11.75) = 23.50 \text{ in}^2$

$\text{LOAD} = \dfrac{69,303 \text{ Lb}}{2} = 34,651 \text{ Lb}$

$S_t = \dfrac{34,651 \text{ Lb}}{23.50 \text{ in}^2}$

$\boxed{S_t = 1475 \text{ Lb/IN}^2}$

BEARING:

$\text{AREA} = (4.0)(11.75) = 47.0 \text{ in}^2$

$S_B = \dfrac{69,303 \text{ Lb}}{47.0 \text{ in}^2}$; $\boxed{S_B = 1474 \text{ Lb/IN}^2}$

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ENGINEERING DEPARTMENT

PREPARED BY R. FLOTH

CHECKED BY

DATE

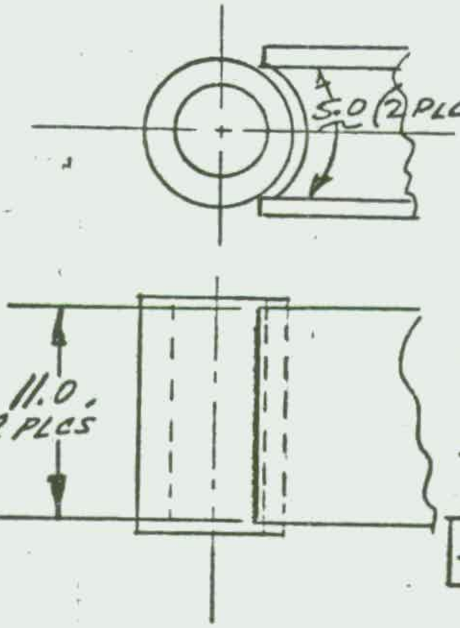
ORDER NO.

PAGE OF

REPORT NO.

EVALUATION FOR "KING PIN" WELDED TUBE STRUCTURE (CONTINUED)

WELDED SUPPORT



LENGTH OF WELD $= (2)(11.0) + (2)(5.0)$

LENGTH OF WELD $= 22.0 + 10.0$

LENGTH OF WELD $= 32.0\text{ in}$

$AREA = (.707)(.50)(32.0)$

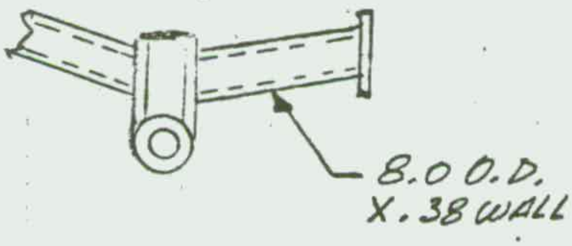
$AREA = 11.31\text{ in}^2$

$$S_{WELD} = \frac{69{,}303\text{ Lb}}{11.31\text{ in}^2}$$

$$\boxed{S_{WELD} = 6{,}127\text{ Lb/in}^2}$$

TORSIONAL STRESS IN TUBE

(ASSUME WORST CONDITION (MOMENT TAKEN OUT ONE SIDE OF SUPPORT ONLY)



$r_1 = 4.00$

$r_0 = 3.62$

$$S_{MAX} = \frac{2Tr_1}{3.14(r_1^4 - r_0^4)} \quad \text{(ROARK)}$$

$$S_{MAX} = \frac{(2)(1{,}152{,}500)(4.00)}{3.14[(4.0)^4 - (3.62)^4]} = \frac{9{,}220{,}000}{3.14[256.0 - 172]}$$

$$S_{MAX} = \frac{9{,}220{,}000}{263.7} = 34{,}963$$

$$\boxed{S_{MAX} = 34{,}963\text{ PSI}}$$

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY R. FLOTH ORDER NO.

CHECKED BY PAGE OF

DATE REPORT NO.

EVALUATION FOR "KING PIN" WELDED TUBE STRUCTURE
(CONTINUED)

BENDING STRESS IN TUBE

$$I = \frac{\pi[(4.0)^4 - (3.62)^4]}{4}$$

$$I = \frac{(3.14)[256.0-172]}{4}$$

$$I = 65.9$$

$$M = \frac{(69,303\#)(47.50)}{8} = 411,486 \text{ in-Lb}$$

$$S_B = \frac{MY}{I} = \frac{(411,486)(4.0)}{65.9}$$

$$\boxed{S_B = 24,976 \text{ Lb/in}^2}$$

TUBE WELDED

CIRCUMFERENCE = 11.38

LENGTH OF WELD = (11.38)(2) = 22.76 in

AREA = (.707)(.38)(22.76)

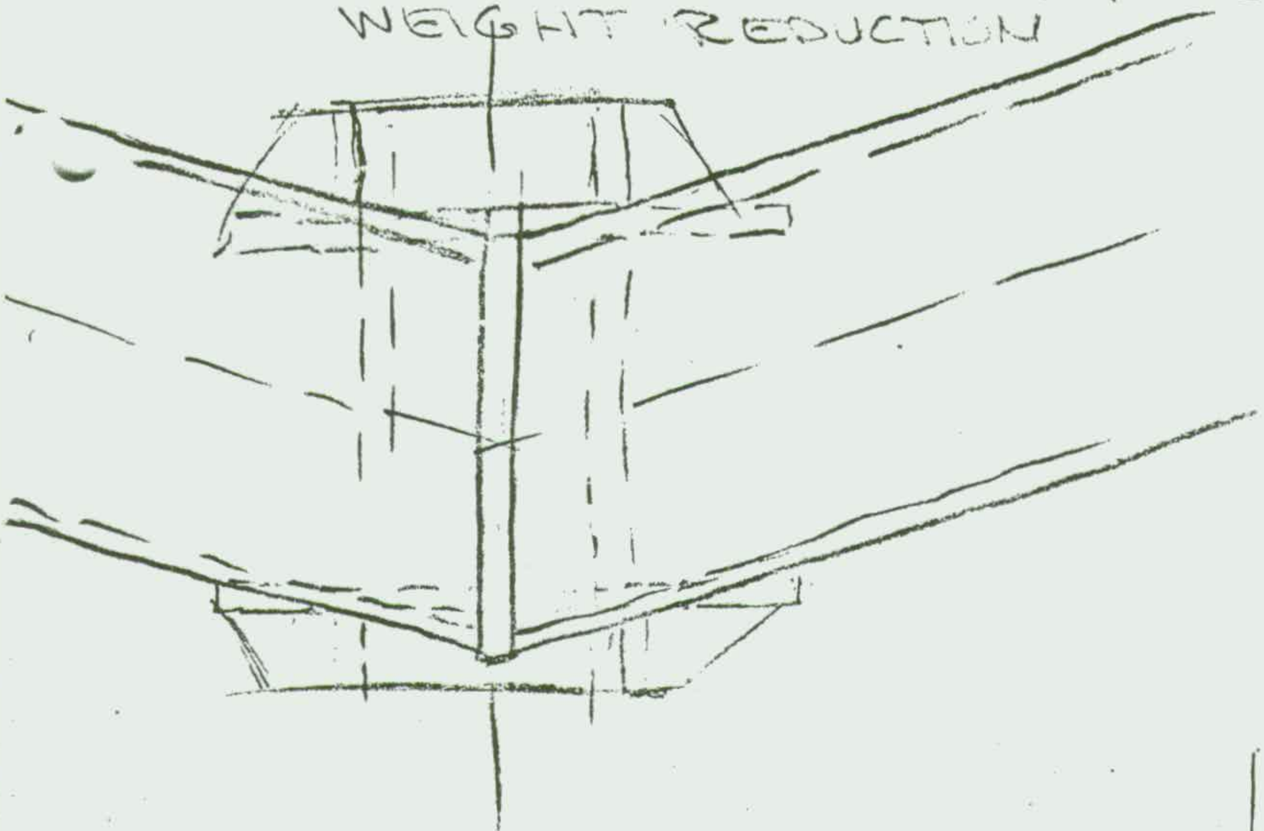
AREA = 6.1 in²

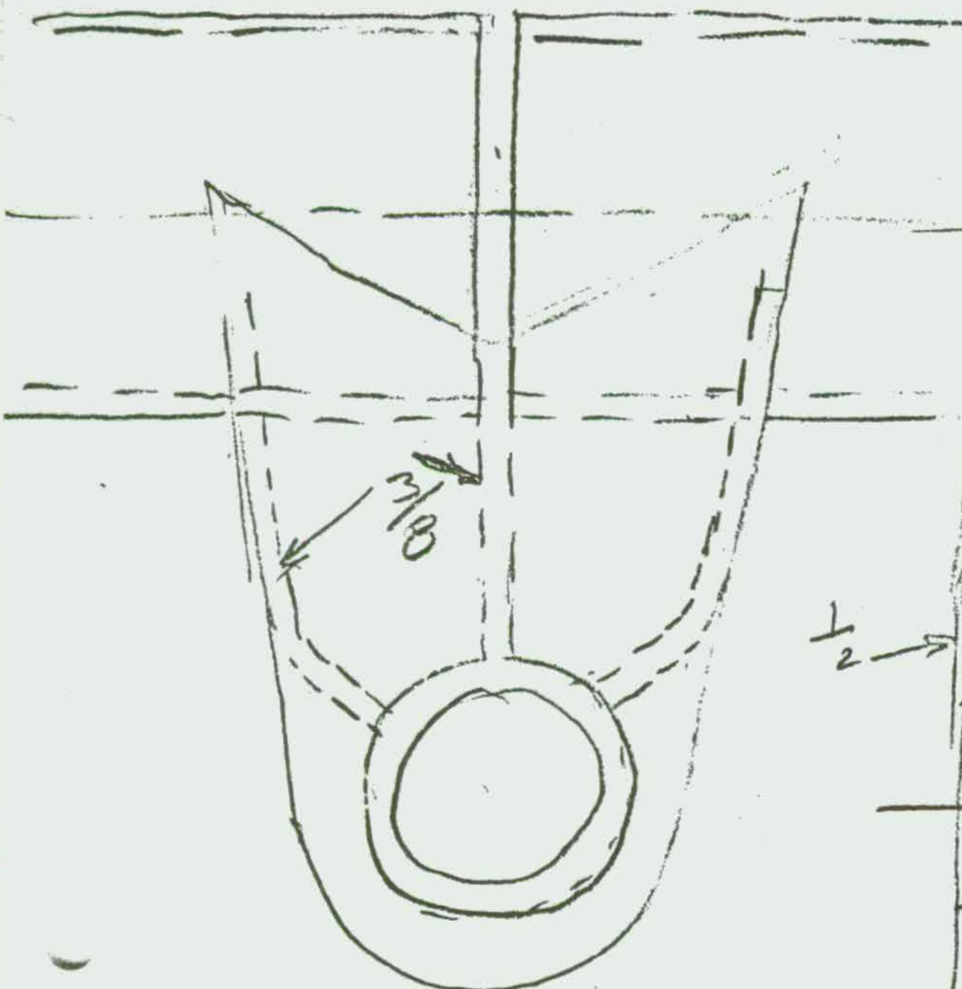
$$S_{WELD} = \frac{69,303 \text{ Lb}}{6.1 \text{ in}^2}$$

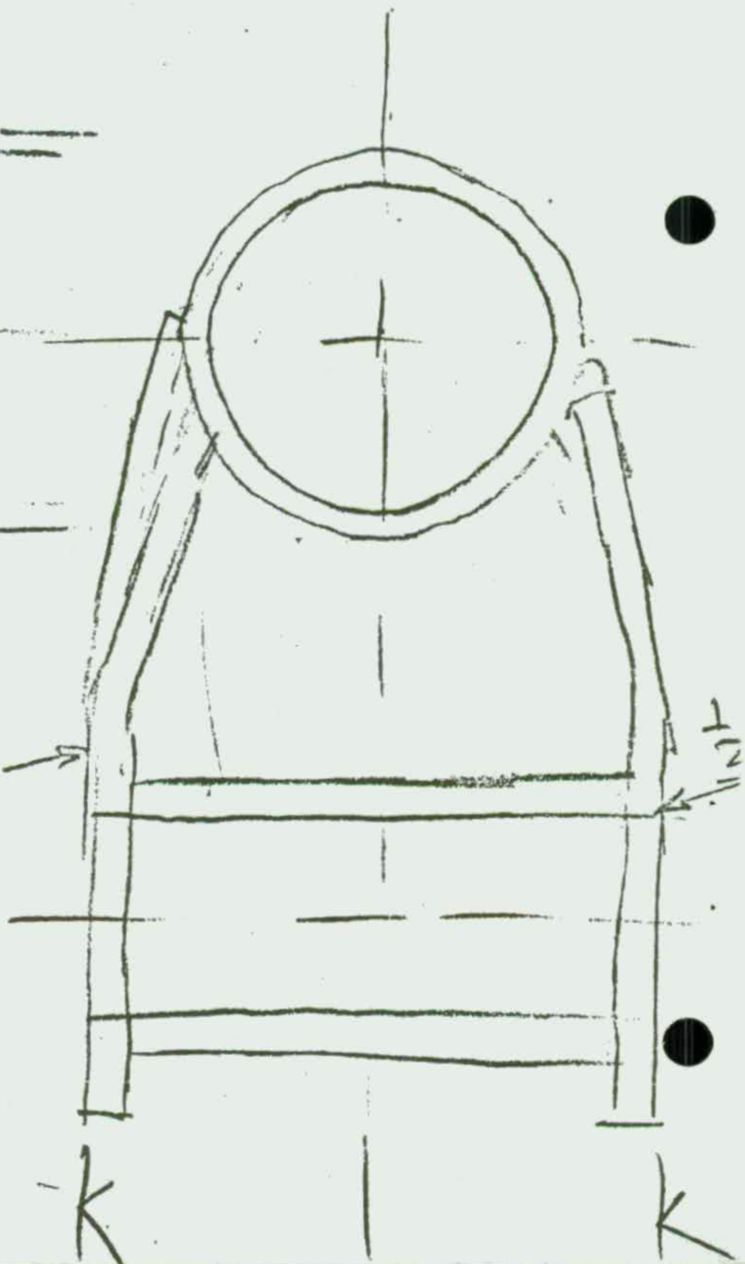
$$\boxed{S_{WELD} = 11,361 \text{ PSI}}$$

PCF-PN-587

POSSIBLE REDESIGN FOR WEIGHT REDUCTION







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ENGINEERING DEPARTMENT

PREPARED BY

CHECKED BY

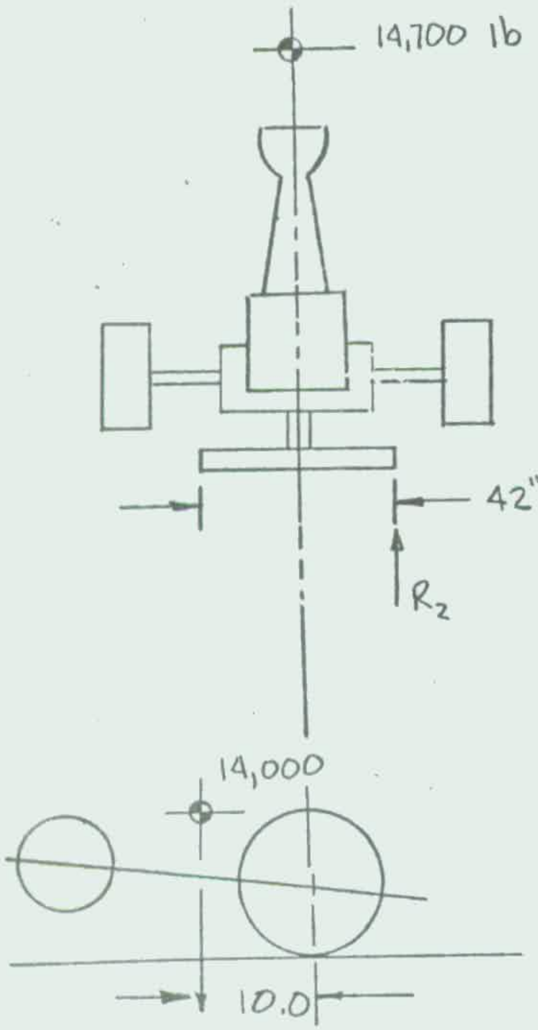
DATE

ORDER NO.

PAGE OF

REPORT NO.

TIPPING RESISTANCE



WITH TUBE IN-LINE:

RESISTANCE = 14,700 x 21 = 309,000 lb - IN

TIPPING MOMENT = 14,000 x 10

= 140,000 lb - IN

POSITION OF TUBE AND TERRAIN MAY REDUCE STABALIZING MOMENT. A LARGER BASE PLATE MAY BE REQUIRED.

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ENGINEERING DEPARTMENT

PREPARED BY

CHECKED BY

DATE

ORDER NO.

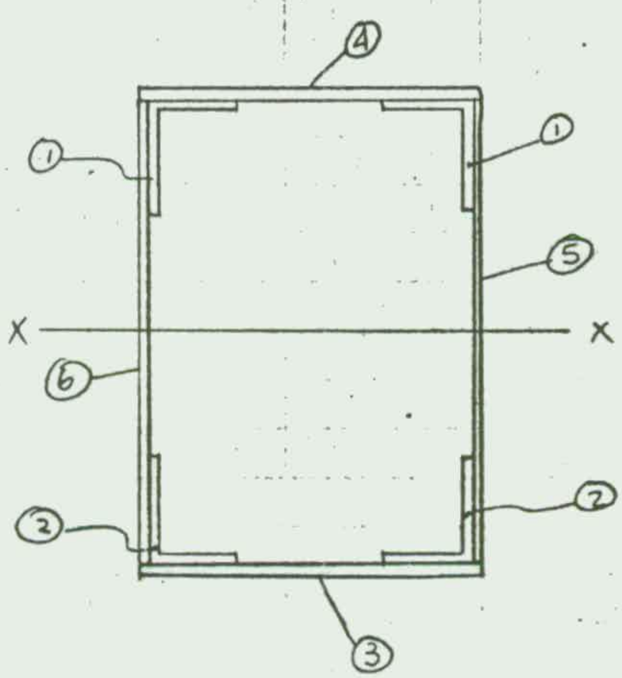
PAGE OF

REPORT NO.

FIND STRESS IN HOWITZER TRAILS DUE TO MOMENT DEVELOPED BY ATLAS.

SECTION F-F OF TRAIL ASSY RIGHT (72F515):

1	72B909	TOP ANGLE	3 x 2 x 3/16
2	72B813	BOTTOM ANGLE	3 x 2 x 3/16
3	72D828	BOTTOM	10.0 x .50
4	72D810	TOP	10.0 x .50
5	72F802	SIDE	12.75 x .25
6	72F825	SIDE	12.75 x .25



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ENGINEERING DEPARTMENT

PREPARED BY ____________ ORDER NO. ____________

CHECKED BY ____________ PAGE ______ OF ______

DATE ____________ REPORT NO. ____________

SECTION	$I_{x\text{-}x}$	
①	$2\left[.82\ \text{IN}^4 + .91(5.43)^2\right] =$	$55\ \text{IN}^4$
②	$2\left[.82\ \text{IN}^4 + .91(5.43)^2\right] =$	$55\ \text{IN}^4$
③ & ④	$2\left[.104\ \text{IN}^4 + 5.0(6.62)^2\right] =$	$438\ \text{IN}^4$
⑤ & ⑥	$(43)\,2 =$	$86\ \text{IN}^4$
	TOTAL	$634\ \text{IN}^4$

FOR A MOMENT OF 1,152,500 IN-lb

AT THE SUPPORT THE MOMENT IS

$\left(\frac{192}{252}\right)(1,152,500) =$ 878,100 lb-IN 60.

INCHES FROM THE HINGE WHERE THE TRAILS ALONE MUST CARRY THE LOAD.

FOR TWO (2) TRAILS THE TOTAL "I"

IS: $1268\ \text{IN}^4$

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ENGINEERING DEPARTMENT

PREPARED BY ______ ORDER NO. ______

CHECKED BY ______ PAGE ______ OF ______

DATE ______ REPORT NO. ______

$$\sigma = \frac{My}{I} = (878,100)(6.88)/1268$$

$$\sigma = \underline{\underline{4,760\ lb/in^2}} \quad \text{(BENDING STRESS ONLY)}$$

FIND THE FORCE REQUIRED IN THE HYDRAULIC CYLINDER TO HOLD THE MOMENT DEVELOPED AT THE HINGE:

$$F = 1,152,500/56/\cos 15^\circ = \underline{\underline{21,300\ lbs}}$$

SINCE A HYDRAULIC CYLINDER WOULD "PRE-STRESS" THE STRUCTURE UNDULY IT IS RECOMMENDED THAT A CLAMPING MECHANISM BE USED WHICH WILL HOLD THE 21,300 lb LOAD.

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY ____ ORDER NO. ____

CHECKED BY ____ PAGE ____ OF ____

DATE ____ REPORT NO. ____

FIND THE TORSIONAL STRESS IN THE TUBE HOLDING THE "KING PIN"

T = 1,152,500 lb-in / 2 = 576,250 lb-in

TUBE SIZE 8.00 OD x .375 WALL

$S_{MAX} = 2Tr_1 / 3.14(r_1^4 - r_0^4)$

$r_1 = 4.00$
$r_0 = 3625$

$S_{MAX} = (2)(576,250)(4) / 3.14(4^4 - 3.625^4)$

$S_{MAX} = 17,610 \text{ lb/in}^2$

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CHECKED BY

DATE 10-8-73

ORDER NO. 80607001

PAGE 1 OF 2

REPORT NO. ATLAS

FIND DRUM DIA OF P-10 WINCH FOR 100 ft OF 1/2 INCH CABLE.

N = NUMBER OF LAYERS

$W = 10.0$
$d = .50$
$D = 6.50$
$L = 100$

$$L = \frac{\pi N}{12} (W-d)\left(\frac{D}{d} + N\right)$$

$$100 = \frac{(3.14)(N)}{12} (9.5)(13 + N)$$

$$100 = 2.45N(13 + N)$$

$$40.82 = 13N + N^2$$

$$N^2 + 13N - 40.82 = 0$$

$$N = \frac{-13 \pm \left[(13)^2 + [(4)(1)(40.82)]\right]^{\frac{1}{2}}}{2}$$

$$N = -6.5 + 9.11 = 2.61$$

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PREPARED BY S. BLACK

CHECKED BY

DATE 10-8-73

ORDER NO. 80607001

PAGE 2 OF 2

REPORT NO. ATLAS

$D = 6.50$

$X = .25/\tan 30° = .25/.577 = .433$

OVER WIRE ROPE $= 6.50 + 2(.50 + .866)$

$= 6.50 + 2.73$

$= 9.23$

WINCH DRUM O.D. $= 9.23 + 2.00 = 11.23$

DESIGN DIMENSION FOR DRUM DIA $= \boxed{11.25 \pm .03}$

SPECIFICATIONS

CARCO MODEL P-10 PLANETARY WINCH

BASIC WINCH DATA

Rated Line Pull . . . . 10,000 Lbs.

Total Reduction

- Low Speed 140:1
- High Speed 26:1

Overall Gear Fffiiciency 85%

Brake Release Pressure . . . . 80 PSI

Weight (Less Wire Rope & Motor) . . . . 150 Lbs.

Oil Capacity . . . . 1-1/2 Qts.

Drum Size:

- Barrel Diameter . . . . 6-1/2"
- Flange Diameter . . . . 13-1/2"
- Barrel Length . . . . 10-0"

Drum Capacity . . . . 366' of 1/2" Wire Rope

EQUATIONS

$$\text{Line Pull (Lbs.)} = \frac{\text{(Motor Torque, In-Lb) (Gear Ratio) (Efficiency \%)}}{\text{(Radius to Center of Wire, In) (100)}}$$

$$\text{Line Speed (FPM)} = \frac{\text{(.5236) (Motor RPM) (Radius to Center of Wire, In)}}{\text{(Gear Ratio)}}$$

* WINCH PERFORMANCE DATA

Motor Input

Torque (In-lb) . . . . . 300　　　Speed (RPM) 1800

Line Pull

Low Speed:		High Speed:	
Bare Drum . . .	10,000 Lbs.	Bare Drum	1,860 Lbs.
Full Drum . . .	5,380 Lbs.	Full Drum	1,000 Lbs.

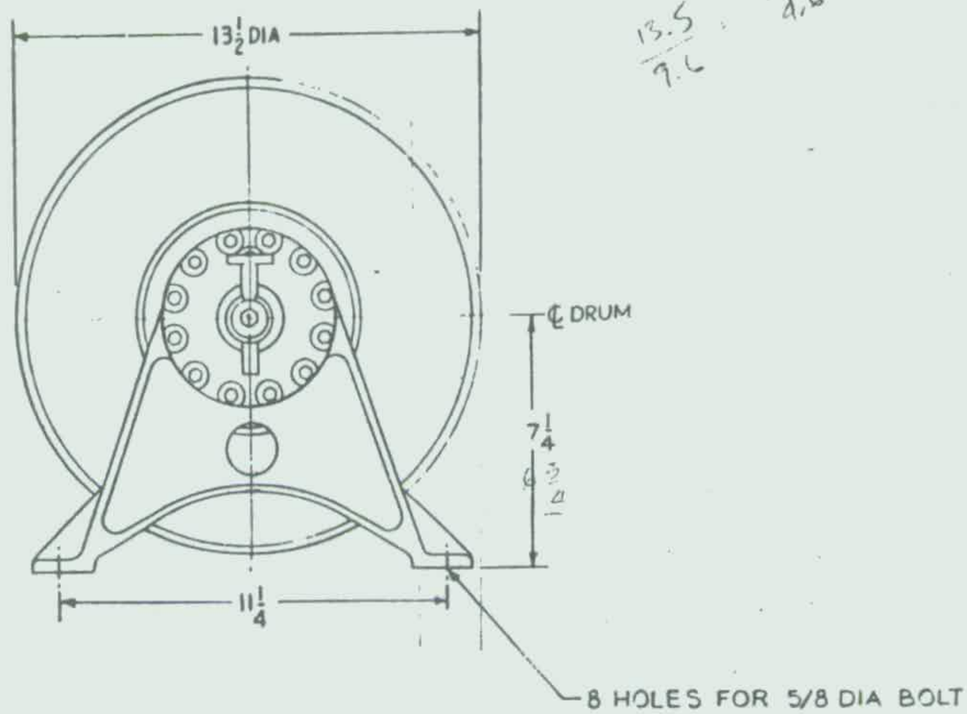
Line Speed

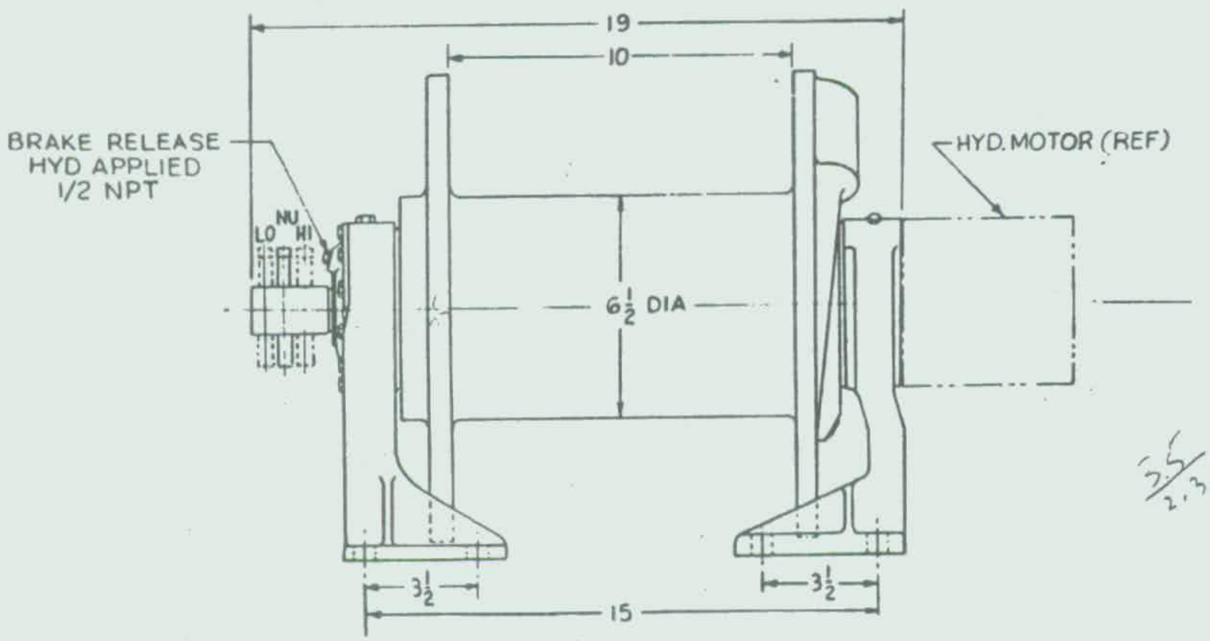
Low Speed:		High Speed:	
Bare Drum	24 FPM	Bare Drum	127 FPM
Full Drum	44 FPM	Full Drum	236 FPM

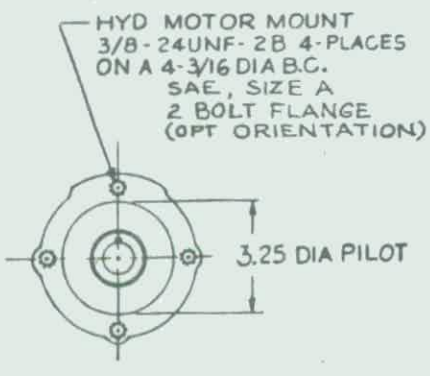
* The above are representative performance figures - based on 1800 RPM input speed.

Form No. L-250 B 7-68

PACIFIC CAR AND FOUNDRY COMPANY
Renton, Washington



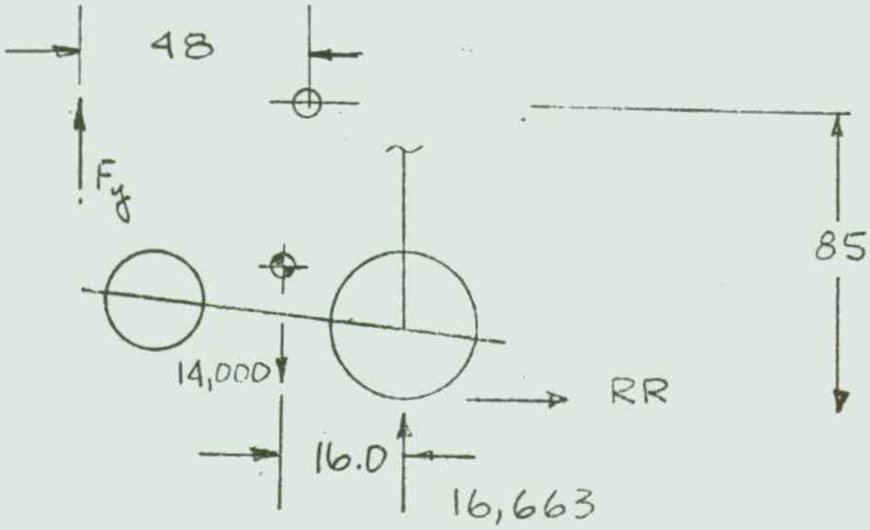




For specifications see reverse.

Form No. L-250F 7-68

PACIFIC CAR AND FOUNDRY COMPANY		
OUTLINE DRAWING P-10 WINCH	D	43201



RR = GVW x R / 1000

RR = 16,663 x 150 / 1000 = 2500 lb

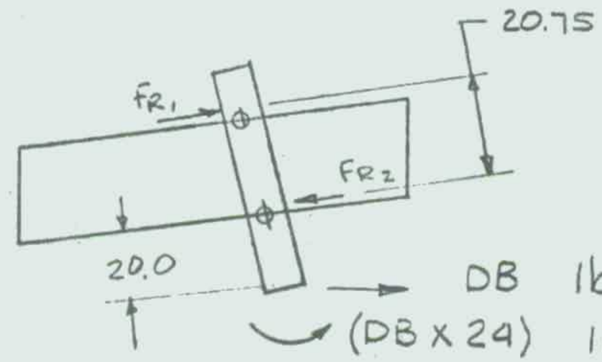
Fy (48) = 14000 (16) + 2500 (85)

Fy = 9100 lb

Fy = FORCE REQUIRED TO RAISE VEHICLE TO TOW POSITION.

ADDING 10% FOR FRICTION LOSSES

Fy = 10,000 #



MAXIMUM DRAWBAR PULL WITHOUT HOWITZER

DB =

$$F_{R_2} = \frac{DB(40.75) + DB \times 24}{20.75} = \frac{DB(64.75)}{20.75} = 3.12\ DB$$

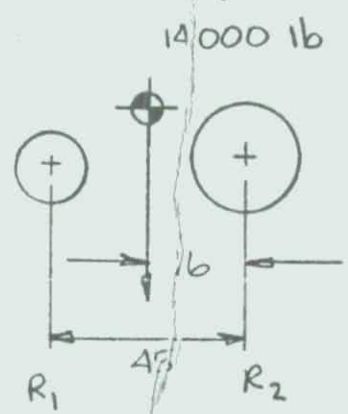
$$F_{R_1} = \frac{20\ DB + 24\ DB}{20.75} = 2.12\ DB$$

FOR DB = WHEEL LOAD: ALL WEIGHT AND FULL TORQUE TO ONE (1) WHEEL

$\Sigma M_{R_1} = 0$

$\therefore\ R_2 = \dfrac{(29)(14{,}000)}{45}$

$R_2 = 9{,}030$ lb



$F_{R_1} = 19{,}100$ lb

$F_{R_2} = 28{,}200$ lb

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

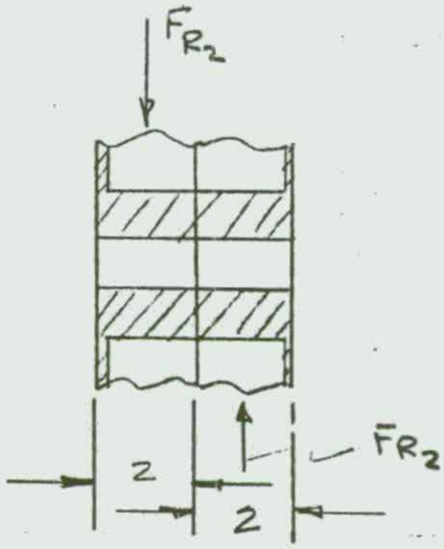
PREPARED BY
CHECKED BY
DATE

ORDER NO.
PAGE 22 OF
REPORT NO.

FOR A 1.50 INCH DIA PIN IN SINGLE SHEAR

(AREA = 1.76 IN^2)

$\tau = F/A = 28{,}200/1.76 = 16{,}000$ PSI



$F_{R_2} = 16{,}000$ lb

$16{,}000 \times 6 = 96{,}000$ PSI

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ENGINEERING DEPARTMENT

PREPARED BY ______ ORDER NO. ______

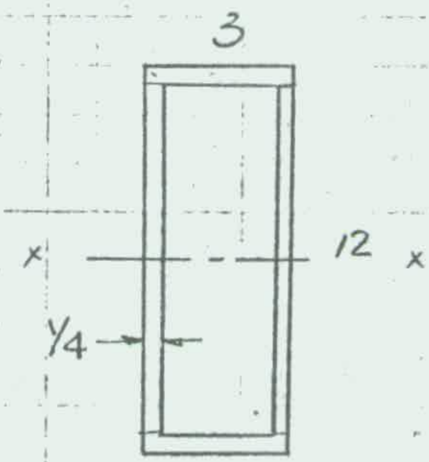
CHECKED BY ______ PAGE 23 OF ______

DATE ______ REPORT NO. ______

FIND THE STRESS IN THE TUBE SUPPORT BEAM.

$$T = 1{,}120{,}000 \text{ lb-IN} / 2 = 560{,}000 \text{ lb-IN}$$

BEAM SECTION:



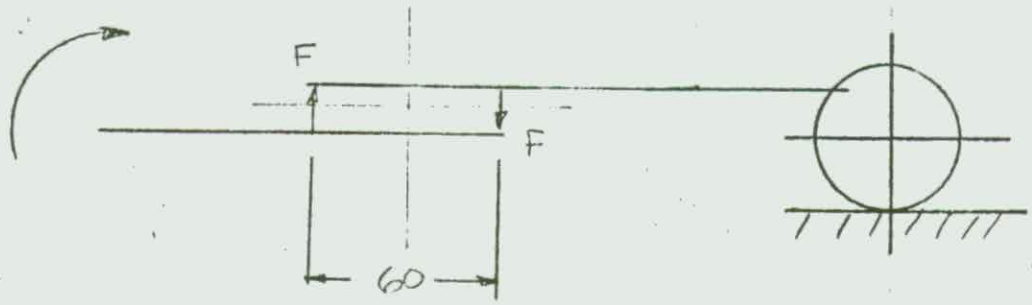
$$I_{xx} = 2(31.69) + 2(.004 + .750(5.87)^2)$$

$$I_{xx} = 64 + 52 = 116 \text{ IN}^4$$

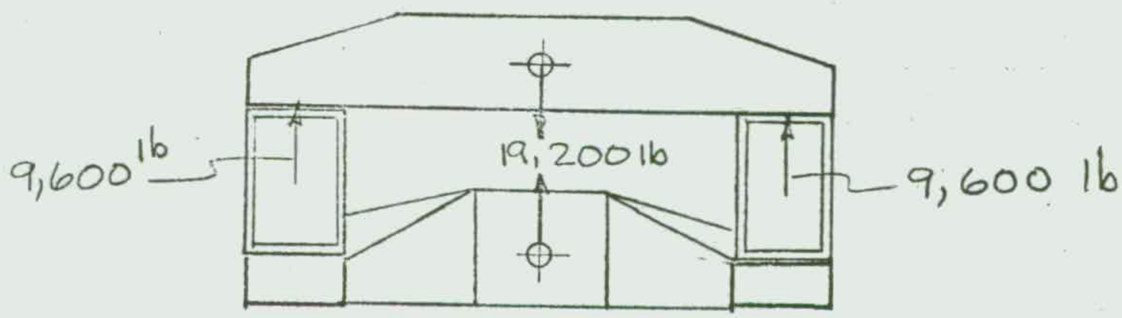
$$\sigma = \frac{My}{I} = (560{,}000)(6)/116 = 28{,}965 \frac{\text{lb}}{\text{IN}^2}$$

FIND FORCE IN BEAM HOLDING TRAILS:

M = 1,151,500 lb-in



F = 1,152,500/60 = 19,200 lb



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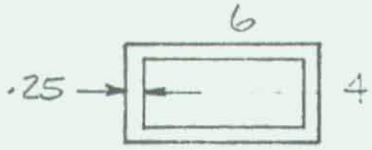
ENGINEERING DEPARTMENT

PREPARED BY________ ORDER NO.________

CHECKED BY________ PAGE 26 OF________

DATE________ REPORT NO.________

BEAM SECTION: 6 X 4 X .25



$$I = \left(.008 + 1.5\left(\frac{3.75}{2}\right)^2 + .89\right) 2$$

$$I = 12 \text{ IN}^4$$

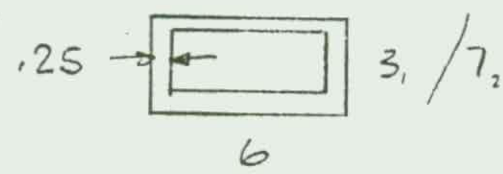
$$M = 9{,}600(13) = 124{,}800$$

$$\sigma = \frac{My}{I} = (124{,}800)(2)/12 = 20800 \ \frac{\text{lb}}{\text{IN}^2}$$

$F = 9{,}600$

$M = 36{,}825$ lb-IN

$I = (3 \times 6 \times .25)$



$I = 2\left(.008 + 1.5\left(\frac{2.75}{2}\right)^2 + .326\right)$

$I = 5.8$ IN^4

$\sigma = \frac{My}{I} = 36{,}825(1.5)/5.8 = 9523 \ \frac{lb}{IN^2}$

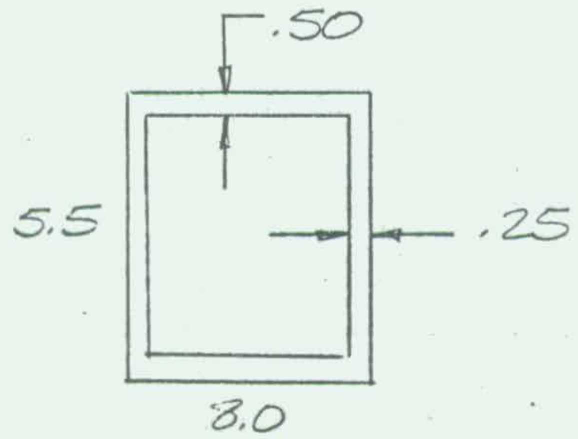
FOR $M = 12{,}275(12) = 147{,}000$ IN-lb

$I = 2\left(.008 + 1.5\left(\frac{6.75}{2}\right)^2 + 5.72\right)$

$I = 23$ IN^4

$\sigma = \frac{Mu}{I} = (147{,}000)(3.5)/23 = 22{,}370 \ \frac{lb}{IN^2}$

T= 140,000 IN-lb



$S_1 = T/2(.25)(8-.25)(5.5-.50)$

$S_2 = T/2(.5)(8-.25)(5.5-.5)$

$S_1 = 140{,}000/.5(7.75)(5) = 7{,}225$ lb/IN²

$S_2 = 140{,}000/(7.75)(5) = 3{,}612$ lb/IN²

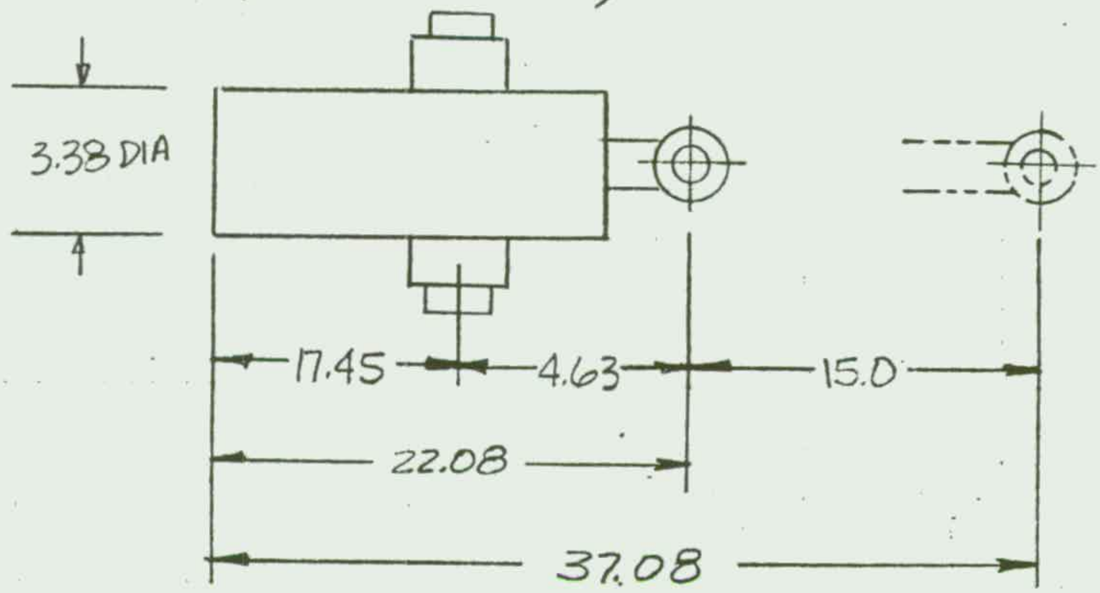
ASSUMING ALL TORQUE IS TRANSMITTED THRU BOOM.

PREPARED BY
CHECKED BY
DATE

ORDER NO.
PAGE 20 A OF
REPORT NO.

BRUNING MALE TRUNNION TYPE 16

3.0" BORE, 1.00" ROD, RE3 TUBE EYE



$6.283 \ \frac{lbf}{PSI}$

F= 12,566 lbs @ 2000 PSI SYS HYD PRESS

$\frac{3.38}{2} = 1.69$

TAPERED SHEAR PIN:

$T = 100,000$ lb-IN

DIA PIN = 1.000 AVE

AVE AREA = .78 IN^2

$F = 100,000/4 = 25,000$ lb

FOR A ROUND SHAFT IN TORSION WITH TRANSVERSE HOLE:

$$\tau_0 = \frac{Tc}{J} \qquad T = 100,000 \text{ lb-IN}$$

$$\frac{J}{c} = \frac{\pi D^3}{16} - \frac{dD^2}{6} \qquad d = 1.000$$

$$\frac{J}{c} = \frac{(3.14)(4)^3}{16} - \frac{(1.0)(4)^2}{6}$$

$$\frac{J}{c} = 12.56 - 2.66 = 9.90$$

$$\tau_0 = 100,000/9.90 = 10,100 \text{ lb/IN}^2$$

$$K_{t_s} = 2.9$$

$$\tau = K_{t_s}\tau_0 = 2.9\,(10,100) = 29,300 \text{ lb/IN}^2$$

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY __________ ORDER NO. __________

CHECKED BY __________ PAGE _____ OF _____

DATE __________ REPORT NO. __________

FOR A PIN LENGTH OF 8.00, THE SMALL END IS: [1.000-2(8)(.02083)]

$$\begin{array}{r} 1.00000 \\ .33333 \\ \hline .66666 \end{array}$$

FOR A TAPER OF 1/4" PER FOOT.

DIA OF SMALL END = .667

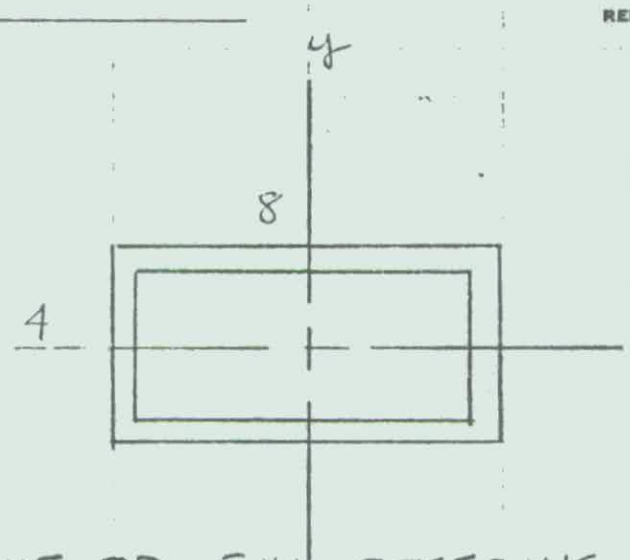
PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY ______ ORDER NO. ______

CHECKED BY ______ PAGE ______ OF ______

DATE ______ REPORT NO. ______



BOOM SECTION

AT SUPPORT

STRESS DUE TO FULLy STEERING TORQUE:

$$I_{yy} = 2(21.33 + .03 + (1.50)(3.75)^2)$$

$$I_{yy} = 85 \text{ IN}^4$$

$$M = 100,000$$

$$y = 4.0$$

$$\sigma = \frac{(100,000)(4.0)}{85} = \underline{\underline{4700 \text{ lb/IN}^2}}$$

+ STRESS DUE TO STATIC OR DYNAMIC LOAD.

PCF-RN-597

SECTION 3

ENGINE MOUNTING

The mounting of an engine must not only provide adequate support for the engine in the desired location, but should do so in a manner that the engine is not subjected to excessive stresses imposed by power take-offs, shock load, or deflection of supporting members. The following section includes recommendations and cautions applicable to the mounting of the engine.

A. Bending Moment Restrictions

In the design of an engine mounting arrangement or power transmitting drive, care must be taken to ensure that the bending moment imposed on the engine is not excessive. A zero bending moment at the point the flywheel housing mounts to the engine is preferred for all engine installations. This is with the unit operational, i. e., all components installed and fluids included.

Where it is impossible to locate the engine mounts so as to achieve a zero bending moment, the allowable bending moment is limited to 1000 ft-lb. A sketch and formulae to determine the bending moment of an existing installation are contained on Chart 3-1.

1. In an automotive installation, the bending moment is based on the static load of the engine installed with all components and accessories and complete with water, oil, etc.

2. For industrial installations, the bending moment must not only include the static loading as for an automotive application, but must also include any dynamic loading imposed by the driven component such as a side pull through a chain drive.

Although the engine weight and center of gravity will vary depending upon the optional components and the mounting of accessories, the weight and center of gravity of the automotive version of all engines are included in Chart D of the Appendix for reference in making the necessary calculations.

11-[illegible]

[illegible] - LORD MFG. CALLED
([illegible]-788-3321)

1. FIRING IMPULSES OF ENGINE ARE MAJOR ITEM TO ISOLATE (NOT SHAFT SPEED)
(2 CYCLE - 4cyl ∴ 4 TIMES SHAFT SPEED)

2. .030" IS TYPICAL STATIC DEFLECTION AT RATED LOAD

3. SOFT MOUNT ON GEAR BOX 3-400 lbs/in
[illegible] [illegible] ON MILITARY APPLICATION

4. WILL SEND ADDITIONAL INFO - WILL BE IN TOWN WEEK OF 11-12-73

11-9-73 DON [illegible] - YOUNG RAD (243-3123)

1. 4-6 ROW CORE DEPENDING ON FAN
(6200 ACFM @ 175°) < 1" STATIC PRESS.

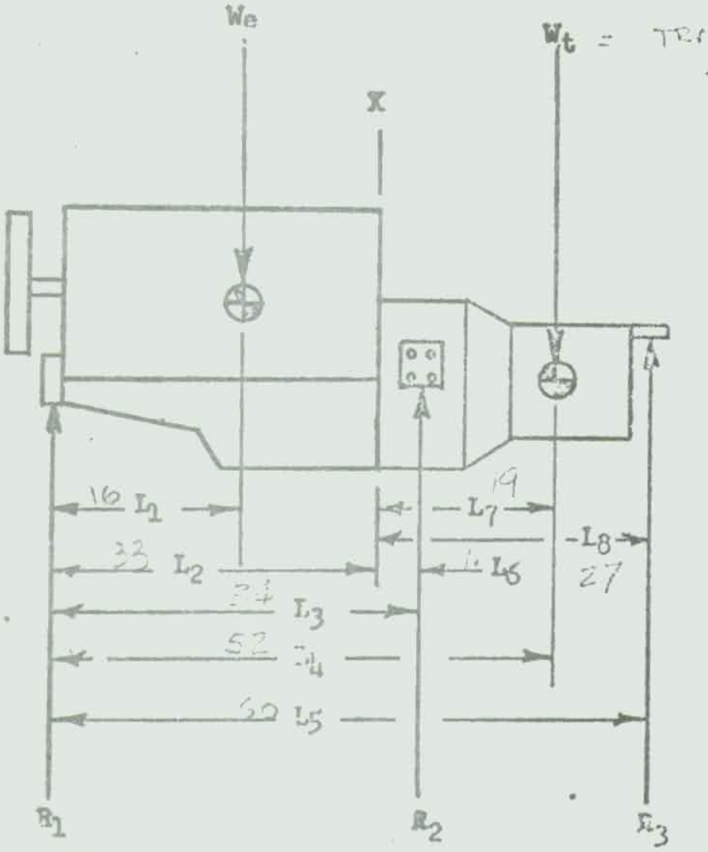
2. NEEDS SPECIFIC FAN INFORMATION.
(SKIP WILL CALL D.D. ON THURS IF NOT RECEIVED.)

RON LUND
315-521-7100

CHART 3-1

DETERMINATION OF BENDING MOMENT FOR AN EXISTING INSTALLATION

W_t = TRANSMISSION + GEAR BOX



644 791 340

W_e = ________ lbs. eng. dry [illegible]
oil [illegible]
water [illegible]
Total (W_e) [illegible]
1250 *

W_t = ________ lbs. trans. dry [illegible]
oil 7
clutch [illegible]
Total (W_t) [illegible]
275
GEARBOX 250
525 *

The engine mount reactions, R_1 and R_2, must first be determined. To do this the tail support reaction, R_3, must be assumed to be zero or a predetermined value which may be built into the unit.

$R_2 = \dfrac{W_eL_1 + W_tL_4 - R_3L_5}{L_3}$ = ________ lbs.

$R_1 = W_e + W_t - R_2 - R_3$ = ________ lbs.

M_x, (Bending Moment Between Flywheel Housing & Block Face) =

$M_x = R_2L_6 + R_3L_8 - W_tL_7$ = ________ in. lbs.

Check: $M_x = R_1L_2 - W_e\,(L_2 - L_1)$ = ________ in. lbs.

Determination of transmission support preload to give zero M_x when locations of R_1 and R_2 are fixed.

$R_3 = \dfrac{W_eL_1 + W_tL_4 - \left(\dfrac{W_tL_7L_3}{L_6}\right)}{L_5 - \left(\dfrac{L_8L_3}{L_6}\right)}$ = 340 lbs.

$\dfrac{(1250)(16) + 525(52) - (525)(19)(34)}{60 - (27)(34)}$

$\dfrac{-291850}{858} =$

47300 -

$R_2 = \dfrac{W_eL_1 + W_tL_4 - R_3L_5}{L_3}$ = 791 lbs.

$\dfrac{(1250)(16) + (525)(52) - (340)(60)}{34}$

$R_1 = W_e + W_t - R_3 - R_2$ = 644 lbs.

Check: $M_x = 0 = R_1L_2 - W_e\,(L_2 - L_1)$ = 2.0 in. lbs.

$644(33) - 1250(17) =$

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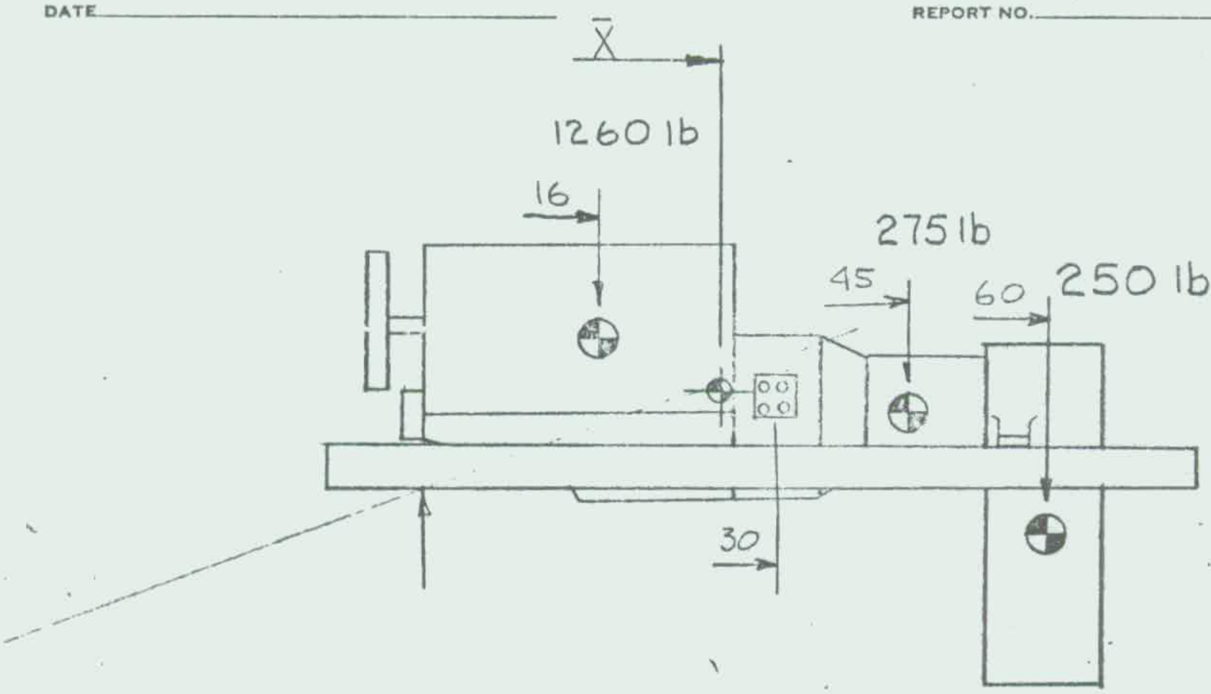
CHECKED BY ____ PAGE ____ OF ____

DATE ____ REPORT NO. ____



$$\bar{X} = \frac{16(1260) + 45(275) + 60(250)}{1785}$$

$$\bar{X} = 27$$

ASSUMING THE TRANSMISSION AND GEAR BOX TO BE ONE UNIT, FIND THE COMBINED C.G.:

$$x = \frac{45(275) + 250(60)}{525} = 52$$

R_1 = 644 lb

R_2 = 791 lb

R_3 = 340 lb

PCF-RN-597

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY

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REPORT NO.

MOUNT #1 (2) LOAD = 644 lb

MOUNT #2 (2) LOAD = 791/2 = 364 lb

MOUNT #3 (1) LOAD = 340/2 = 170 lb

DISTURBING FREQUENCY RANGE:

$\frac{600(4)}{60} = 40$ $\frac{2800(4)}{60} = 254$

PART NO. $\frac{\text{ACTUAL LOAD}}{\text{RATED LOAD}}$ X RATED DEF. = ACTUAL DEF

J-6210-1 644/765 x .078 = .0655 IN

J-8006-1 364/500 x .075 = .0546 IN

WHAT ABOUT 10G SHOCK LOAD ?? (OK.)

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

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CHECKED BY ______ PAGE ______ OF ______

DATE ______ REPORT NO. ______

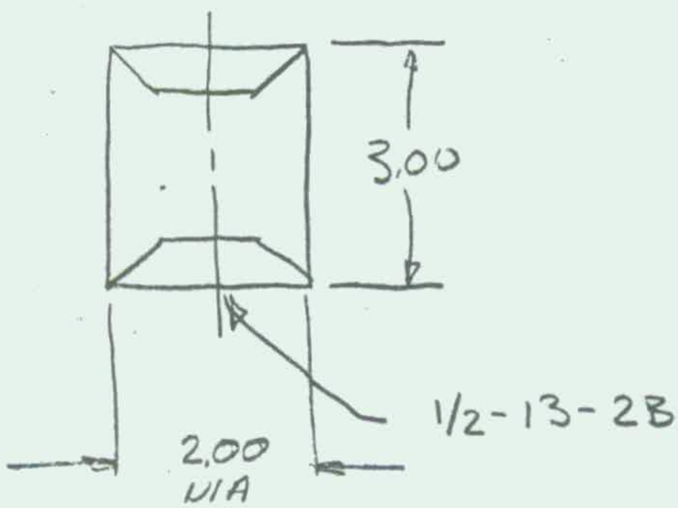
TRANSFER CASE MOUNT

REQUIRED LOAD = 340 lb -

USING TWO MOUNTS 340/2 = 170 lbs

J-3424-49 K_c = 450

$\Delta = \dfrac{170}{450} = .378$ } VERTICAL DEFLECTION

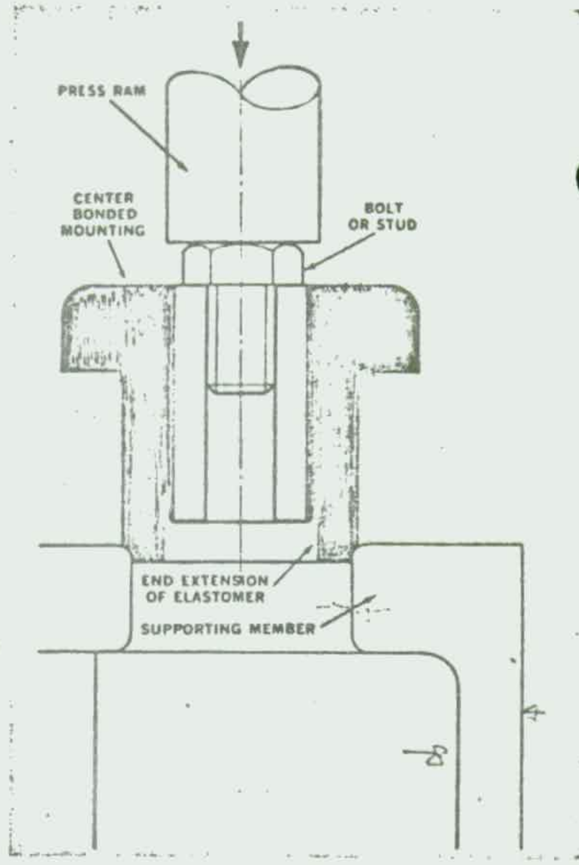


TRANSFER CASE MOUNT

NTER
NDED
UNTINGS

Center Bonded Mountings

1. ISOLATE FIRING IMPULSES
2. AVE STATIC DEF. (.080") AT RATED LOAD
3. SOFT MOUNT ON GEAR BOX 4-800 LBS./INCH



The Center Bonded Mountings have been designed to provide multi-directional isolation of engines, pumps, compressors, etc. The mount provides a simple one-piece design. Because of the complexity of vibrating masses and the interaction between them, it is difficult to select a mounting based on load rating only. Further, since a vibration source may excite the total mass in two or more directions, commonly called coupling, one may have to try several stiffnesses in order to obtain an optimum solution. Generally speaking, one should begin with isolating the primary excitation, usually the operating speed of the unit.

The load ratings indicated are for static gravity loads. The mountings are capable of handling dynamic torque loads of 2.5 to three times the rated loads.

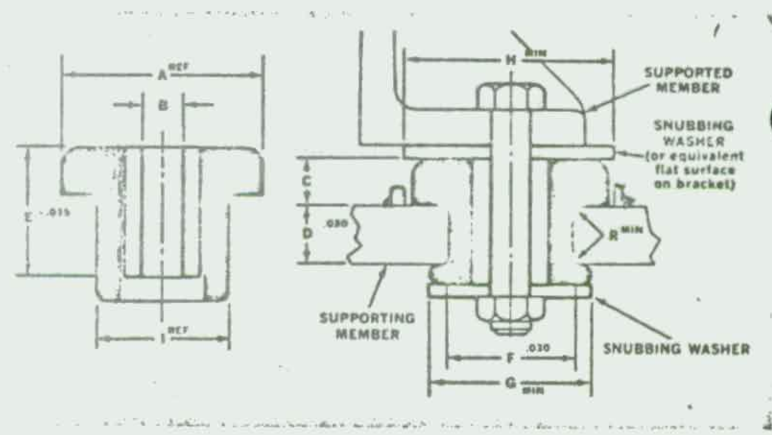
The spring rate can be determined by dividing the rated load by the rated deflection. The rated load is in the axial direction. Radial loads are acceptable; but static radial loads are not recommended.

installation: easy economical, uniform

Mountings may be installed in supporting member with rebound shoulder down, or in supported member with rebound shoulder up.

Installation is a simple, four-step procedure:

1. Lubricate the mounting and socket lightly with rubber lubricant or water. Lubricant available from International Products Corporation, Trenton, N. J.
2. Insert assembly fixtures or driving bolt through inner member. Take care that driving members do not overhang spine outside diameter or damage may result to the elastomer.
3. Apply sufficient pressure to seat the mounting socket.
4. Tighten the nut until the supported member and snubbing washer are snug against the inner member. The rebound shoulder is formed automatically. The resultant precompression will deliver published design ratings and assure optimum performance.



specifications

Part No.	Rated[1] Load (Lbs.)	Rated Deflection (In.)	A	B	C[3]	D	E	F	G	H	I	R
J-7153-1	125	.018	1.09	.40	.19	.31	.69	.75	1.12	1.25	.81	.06
J-6642-1	225	.035	1.75	.47	.38	.38	1.00	1.12	1.50	2.00	1.24	.06
J-6642-7	225	.035	1.75	.52	.38	.38	1.00	1.12	1.50	2.00	1.24	.06
J-6642-9	225	.028	1.75	.52	.38	.38	1.00	1.12	1.50	2.00	1.24	.06
J-6256-1	220	.037	2.00	.53	.45	.62	1.38	1.25	1.75	2.25	1.35	.06
J-6256-3	320	.029	2.00	.53	.45	.62	1.38	1.25	1.75	2.25	1.35	.06
J-6256-9	250	.028	2.00	.65	.45	.25	1.00	1.25	1.75	2.25	1.35	.03
J-6256-10	200	.040	2.00	.53	.45	.25	1.00	1.25	1.75	2.25	1.35	.03
J-6256-12	320	.033	2.00	.64	.45	.62	1.38	1.25	1.75	2.25	1.35	.06
J-6256-22	220	.037	2.00	.64	.45	.62	1.38	1.25	1.75	2.25	1.35	.06
(2) ENG FLWHL HSG → J-8006-1	500	.075	2.50	.64	.56	.75	1.75	1.50	2.25	2.88	1.62	.06
J-8006-6	650	.042	2.50	.64	.56	.75	1.75	1.50	2.25	2.88	1.62	.06
(1) ENG. FRONT → J-6210-1	765	.078	2.98	.64	.71	.93	2.00	1.81	2.50	3.50	1.98	.12
J-6210-4	950	.068	2.98	.64	.71	.93	2.00	1.81	2.50	3.50	1.98	.12
J-6210-36	765	.078	2.98	.64	.71	.50	[illegible]	1.81	2.50	3.50	1.98	.12
J-6198-1	900	.10	3.75	.77	.94	.75	2.12	2.00	2.75	4.25	2.25	.12
J-6198-2	900	.07	3.75	.77	.94	.75	2.12	2.00	2.75	4.25	2.25	.12
J-6198-3	900	.05	3.75	.77	.94	.75	2.12	2.00	2.75	4.25	2.23	.12
CB-1009-1	1200	.12	3.75	.77	.94	.75	2.00	2.00	3.00	4.25	2.23	.12
CB-1009-9	1600	.08	3.75	.77	.94	.75	2.00	2.00	3.00	4.25	2.23	.12
J-8635-1	1800	.145	4.50	1.02	1.12	1.75	3.50	2.75	4.00	5.00	2.98	.12

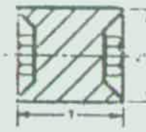
NOTES:
[1] Special load ratings available on request.
[2] Unless otherwise specified all dimensions are nominal. See drawings for tolerances.
[3] Head thickness after assembly with no external load.

Shear Sandwich Mountings

WICH
NTS

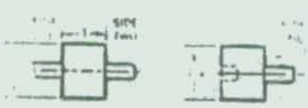
J-3424 TRANSFER CASE(2)

RADIATOR



Part No.	Elastomer	SHEAR Load (lbs.)	SHEAR Kr	COMPRESSION Load (lbs.)	COMPRESSION Kc	T (inch)	SIDE ONE Stud Length or Minimum Thread Depth (inch)	SIDE ONE Thread	SIDE TWO Stud Length or Minimum Thread Depth (inch)	SIDE TWO Thread
J-3424-49	NR	24	60	190	450	3.00	.40	½-13-2B	.40	½-13-2B
J-3424-9	NR	25	75	210	638	2.62	.40	½-13-2B	.40	½-13-2B
J-3424-8	NR	33	100	280	850	2.62	.40	½-13-2B	.40	½-13-2B
J-3424-7	NR	34	150	310	1,350	2.12	.40	½-13-2B	.40	½-13-2B
J-3424-30	NR	39	250	385	2,500	1.75	.40	½-13-2B	.40	½-13-2B
J-3424-6	NR	46	200	415	1,800	2.12	.40	½-13-2B	.40	½-13-2B
J-3424-16	NR	57	375	575	3,750	1.75	.40	½-13-2B	.40	½-13-2B
J-3424-80	NR	57.5	250	515	2,250	2.12	.50	½-13-2B	.40	½-13-2B
J-3424-70	NR	103	450	931	4,050	2.12	.40	½-13-2B	.40	½-13-2B
J-3424-5	N	34	150	310	1,350	2.12	.40	½-13-2B	.40	½-13-2B
J-3424-2	N	46	200	415	1,800	2.12	.40	½-13-2B	.40	½-13-2B
J-3424-3	N	80	350	725	3,150	2.12	.40	½-13-2B	.40	½-13-2B
J-3424-21	N	92	400	828	3,600	2.12	.40	½-13-2B	.40	½-13-2B

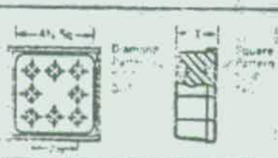
J-4624



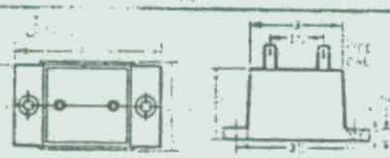
TAPPED ENDS

Part No.	Elastomer	SHEAR Load (lbs.)	SHEAR Kr	COMPRESSION Load (lbs.)	COMPRESSION Kc	T (inch)	SIDE ONE Stud Length or Minimum Thread Depth (inch)	SIDE ONE Thread	SIDE TWO Stud Length or Minimum Thread Depth (inch)	SIDE TWO Thread
J-4624-165	NR	4	95	23	560	.75	.62	¼-20-2A	.25	¼-20-2B
J-4624-150	NR	5	125	40	750	.75	.38	¼-20-2A	.25	¼-20-2B
J-4624-19	NR	6	55	36	320	.75	.38	¼-20-2A	.38	¼-20-2A
J-4624-17	NR	6.5	60	40	360	.75	.38	¼-20-2A	.38	¼-20-2A
J-4624-10	NR	40	750	168	4,200	.75	.38	¼-20-2A	.25	¼-20-2B
J-4624-109	N	3	28	22	195	.75	.38	¼-20-2A	.38	¼-20-2A
J-4624-176	N	6	55	32	290	.75	.38	¼-20-2A	.38	¼-20-2A
J-4624-53	N	8	170	44	1,100	.75	.50	¼-20-2A	.25	¼-20-2B
J-4624-225	N	9.5	190	56	1,121	.75	.75	¼-20-2A	.25	¼-20-2B
J-4624-69	N	11	100	70	620	.75	.38	6-32-2A	.38	6-32-2A
J-4624-4	N	11	100	70	620	.75	.38	¼-20-2A	.38	6-32-2A
J-4624-1	N	12	105	64	620	.75	.38	¼-20-2A	.38	¼-20-2A
J-4624-14	N	12	105	64	620	.75	.50	¼-20-2A	.50	¼-20-2A
J-4624-27	N	12	105	64	620	.75	.75	¼-20-2A	.75	¼-20-2A
J-4624-23	N	17	150	110	1,000	.75	.62	¼-20-2A	.62	¼-20-2A
J-4624-3	N	22	200	135	1,200	.75	.88	5/16-18-2A	.50	5/16-18-2A
J-4624-16	N	22	200	135	1,200	.75	.88	5/16-18-2A	.50	5/16-18-2A
J-4624-45	N	22	200	135	1,200	.75	.75	5/16-18-2A	.75	5/16-18-2A
J-4624-85	N	22	200	135	1,200	.75	1.38	5/16-18-2A	1.12	5/16-18-2A
J-4624-32	N	29	260	200	1,800	.75	.50	¼-20-2A	.50	¼-20-2A

J-5130



Part No.	Elastomer	SHEAR Load (lbs.)	SHEAR Kr	COMPRESSION Load (lbs.)	COMPRESSION Kc	T (inch)	SIDE ONE Stud Length or Minimum Thread Depth (inch)	SIDE ONE Thread	SIDE TWO Stud Length or Minimum Thread Depth (inch)	SIDE TWO Thread
J-5130-55	NR	450	1,400	3,400	10,500	2.12	.53	½-20-2B	.53	½-20-2B
J-5130-1	N	550	1,700	4,130	12,750	2.12	.53	½-20-2B	.53	½-20-2B



Part No.	Elastomer	SHEAR Load (lbs.)	SHEAR Kr	COMPRESSION Load (lbs.)	COMPRESSION Kc	T (inch)	SIDE ONE Stud Length or Minimum Thread Depth (inch)	SIDE ONE Thread	SIDE TWO Stud Length or Minimum Thread Depth (inch)	SIDE TWO Thread
J-5294-21	N	130	350	1,050	2,800	2.25	.81	5/16-18-2A	.38/19**	Flange
J-5294-2	N	190	500	1,500	4,000	2.25	.81	5/16-18-2A	.38/19**	Flange

Part No.	Elastomer	SHEAR Load (lbs.)	SHEAR Kr	COMPRESSION Load (lbs.)	COMPRESSION Kc	T (inch)	SIDE ONE Stud Length or Minimum Thread Depth (inch)	SIDE ONE Thread	SIDE TWO Stud Length or Minimum Thread Depth (inch)	SIDE TWO Thread
J-5425-15	NR	92	175	596	1,140	3.00	1.25	½-13-2A	1.25	½-13-2A
J-5425-30	B	138	250	900	1,625	3.00	1.31	½-13-2A	1.31	½-13-2A
J-5425-1	NR	157	300	1,021	1,950	3.00	1.25	½-13-2A	1.25	½-13-2A
J-5425-16	B	221	550	1,670	4,125	2.25	1.50	½-13-2A	1.31	½-13-2A
J-5425-6	NR	300	600	2,040	3,900	3.00	1.25	½-13-2A	1.25	½-13-2A

N – Neoprene; NR – Natural Rubber; B – Buna; BTR – Lord Broad Temperature Range Elastomer

DETROIT DIESEL

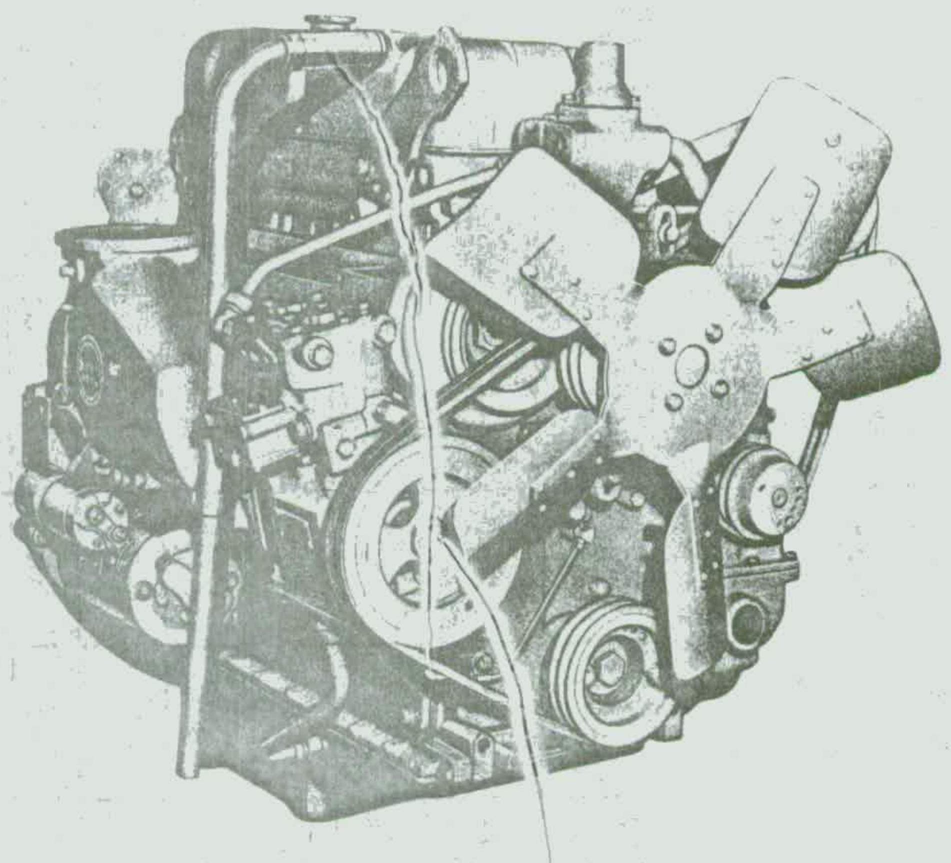
TRUCK MODELS

4-53N

116 HP 130 HP 140 HP

MODELS

4-53N	5047-5040 5047-7040 5047-7041



DETROIT DIESEL

Model 5047-7040

SPECIFICATIONS

	4-53 (N40)	4-53 (N45)	4-53 (N50)
Model	Hi-Economy	Balanced Match	Hi-Performance
Engine Type	Two Cycle	Two Cycle	Two Cycle
No. of Cylinders	4	4	4
Bore and Stroke	3⅞ in. x 4½ in.	3⅞ in. x 4½ in.	3⅞ in. x 4½ in.
Two Cycle Displacement (Every Downstroke a Powerstroke)	212 cu. in.	212 cu. in.	212 cu. in.
Rated Brake Horsepower—2800 RPM	116	130	140
Torque	259 lb. ft. @ 1500 RPM	278 lb. ft. @ 1800 RPM	286 lb. ft. @ 1800 RPM
Compression Ratio	21 to 1	21 to 1	21 to 1
Net Weight (Dry) with Standard Equipment	1190 lbs.	1190 lbs.	1190 lbs.

STANDARD EQUIPMENT

Air Compressor—7¼ CF

Air Inlet Housing—Manual shutdown with 50″ cable

Exhaust Manifold—With center horizontal outlet and flange

Fan—22″—5 blade, suction

Flywheel—SAE #2 for 14″ clutch

Flywheel Housing—SAE #2

Generator—12 volt—25 amp.

Governor—Limiting speed

Injectors—Cam-operated, Unit type

Lube Oil Filter—Full flow filter

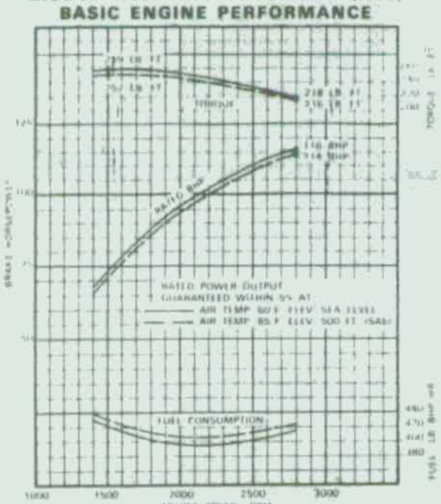
Oil Pan and Distribution System—10 degree inclination

Starting Equipment—12 volt—Sprag clutch

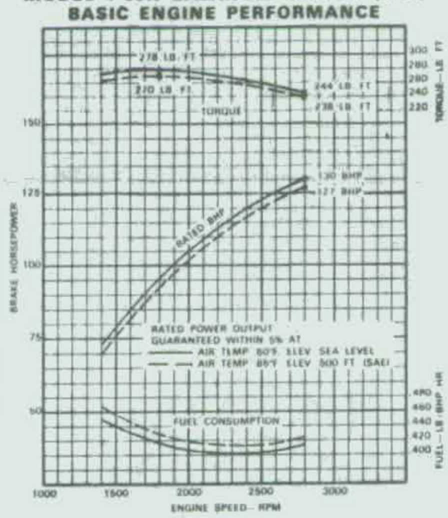
OPTIONAL AND EXTRA EQUIPMENT AVAILABLE

PERFORMANCE

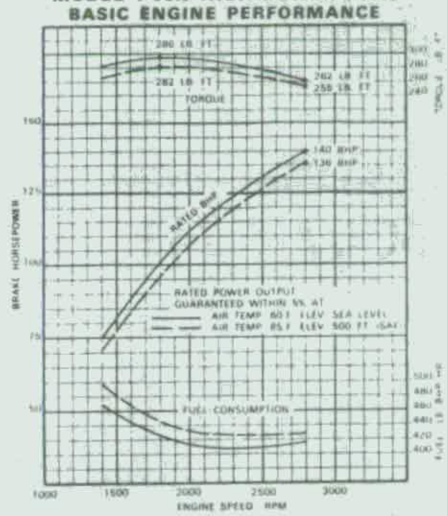
MODEL 4-53N HIGH ECONOMY (N40) BASIC ENGINE PERFORMANCE



MODEL 4-53N BALANCED MATCH (N45) BASIC ENGINE PERFORMANCE



MODEL 4-53N HIGH POWER (N50) BASIC ENGINE PERFORMANCE



Ratings Explanation

[illegible] power rating for [illegible]

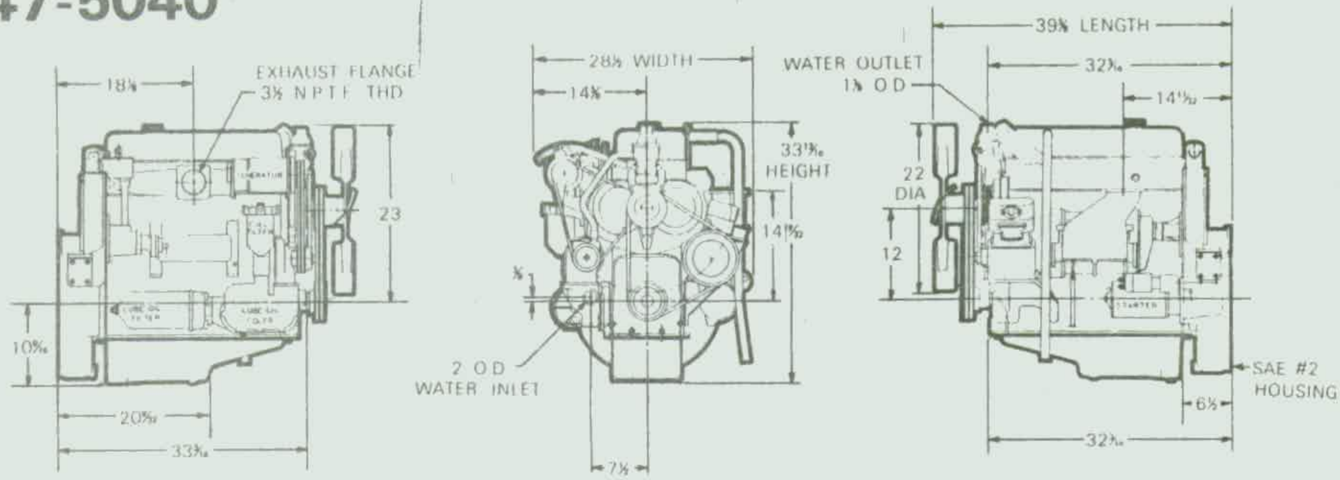
FUEL CONSUMPTION CURVE shows fuel used in pounds per brake horsepower hour

[illegible] RATINGS [illegible] power requirements for accessory [illegible]

For complete engine specifications for your particular application, see your authorized Detroit Diesel representative.

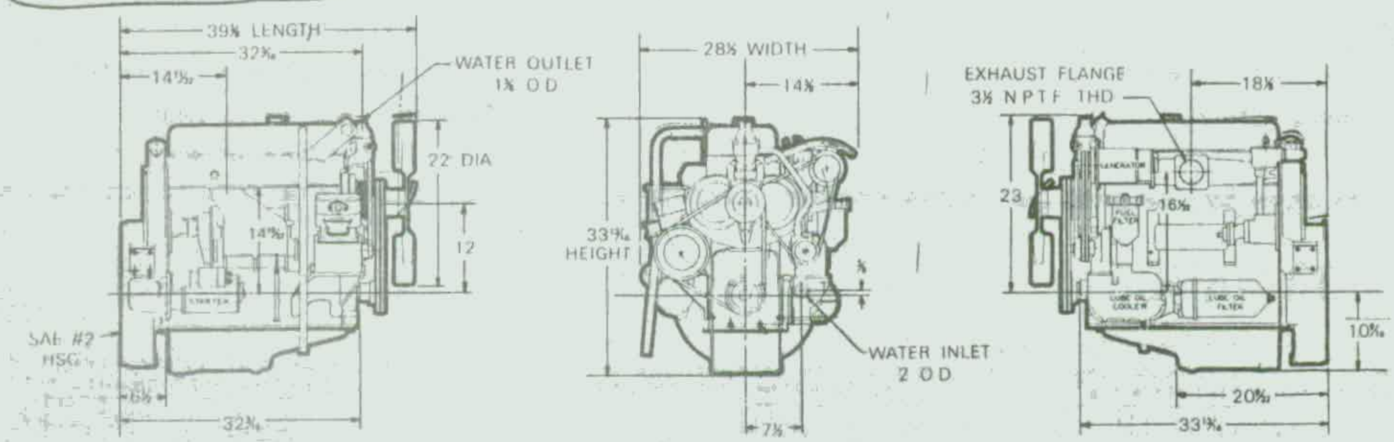
PRINCIPAL DIMENSIONS

5047-5040



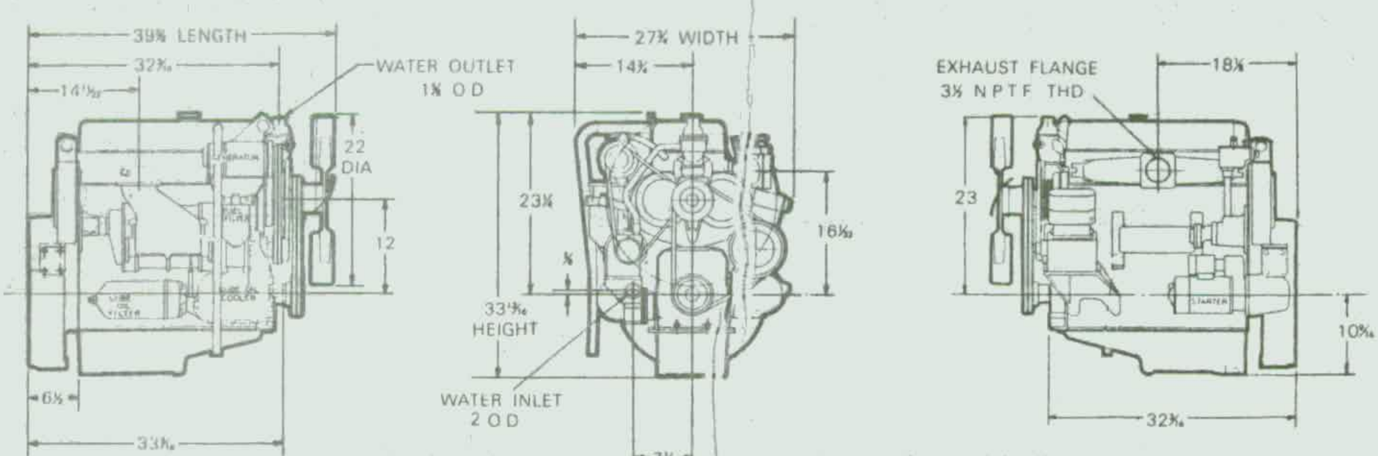
FOR COMPLETE DIMENSIONS REFER TO INST. DWG. 2SA297

5047-7040

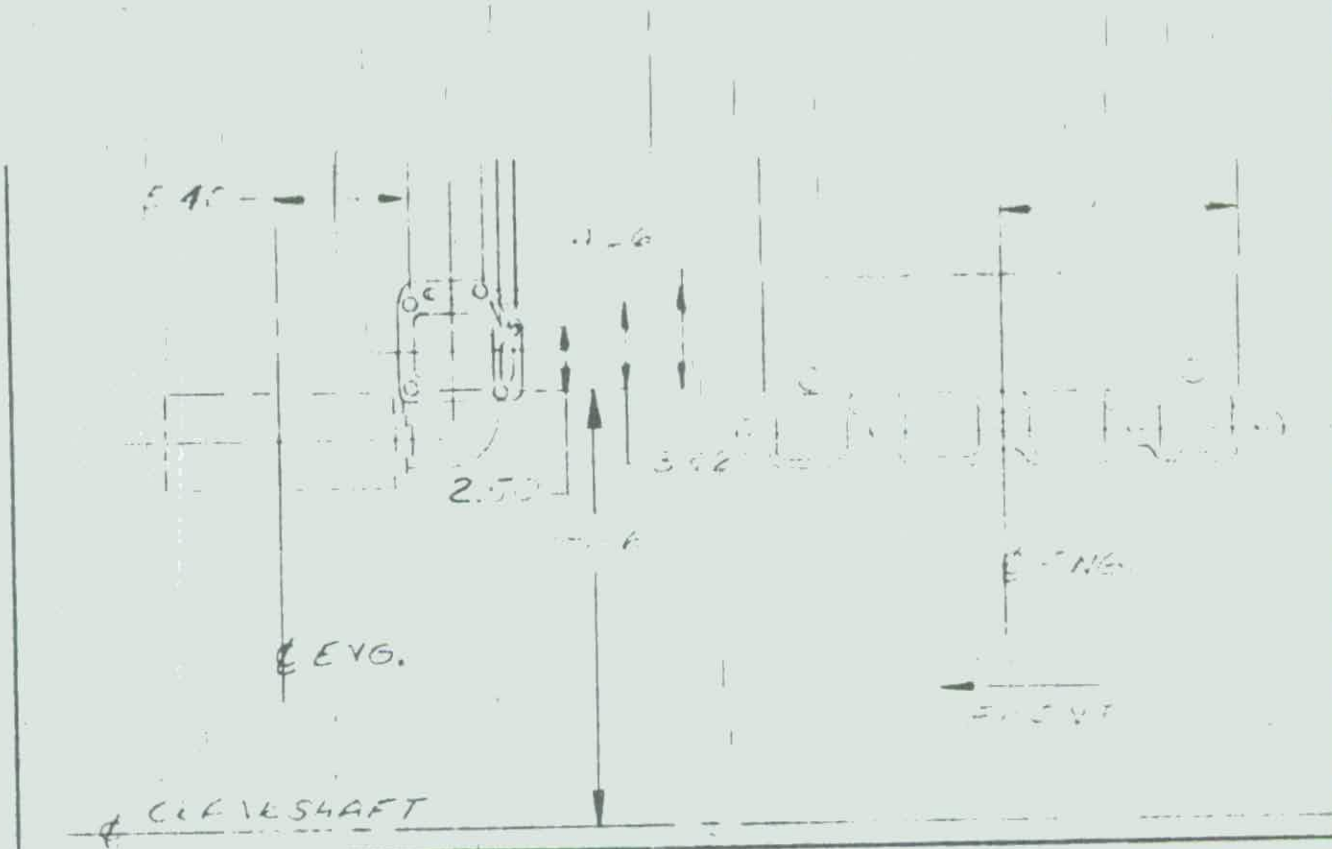


FOR COMPLETE DIMENSIONS REFER TO INST. DWG. 2SA270

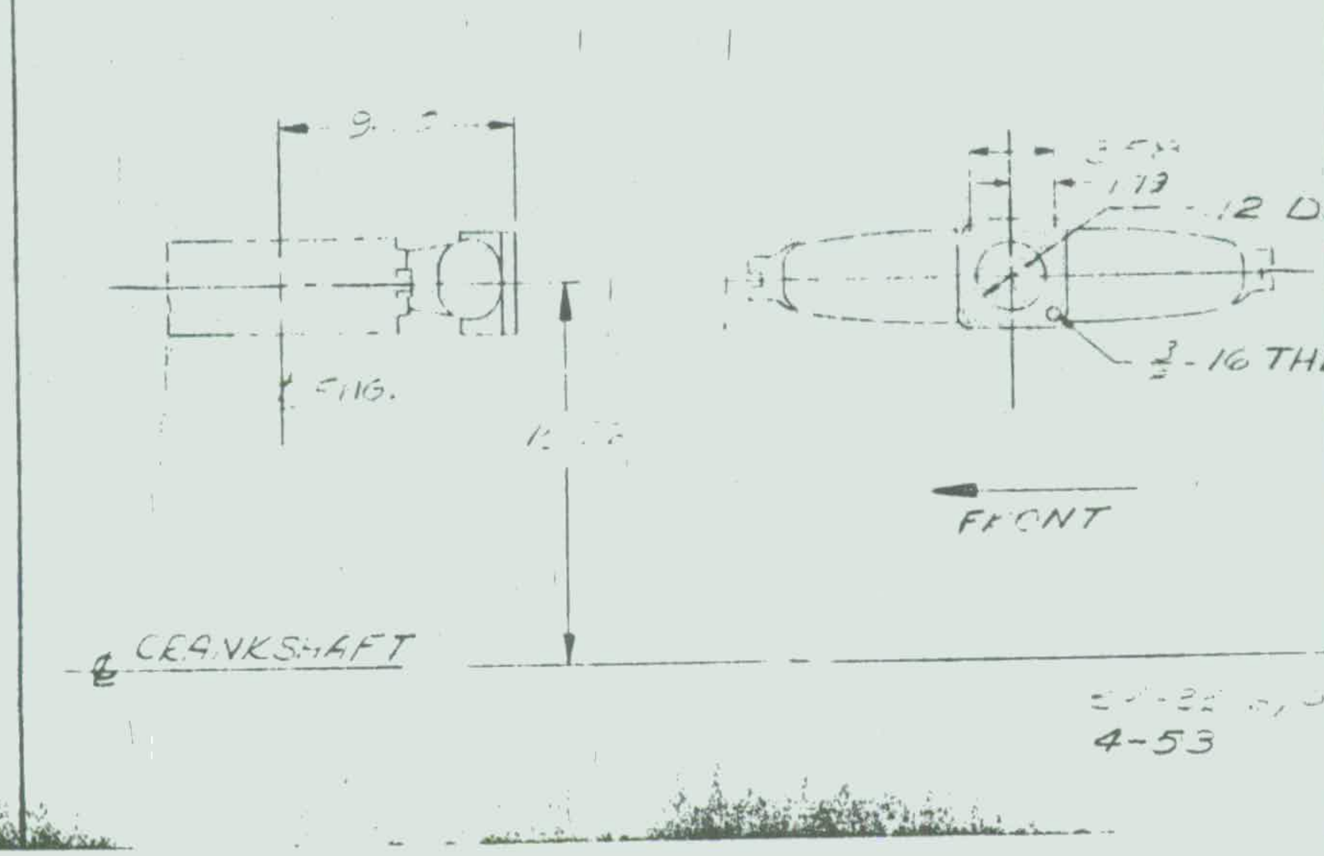
5047-7041

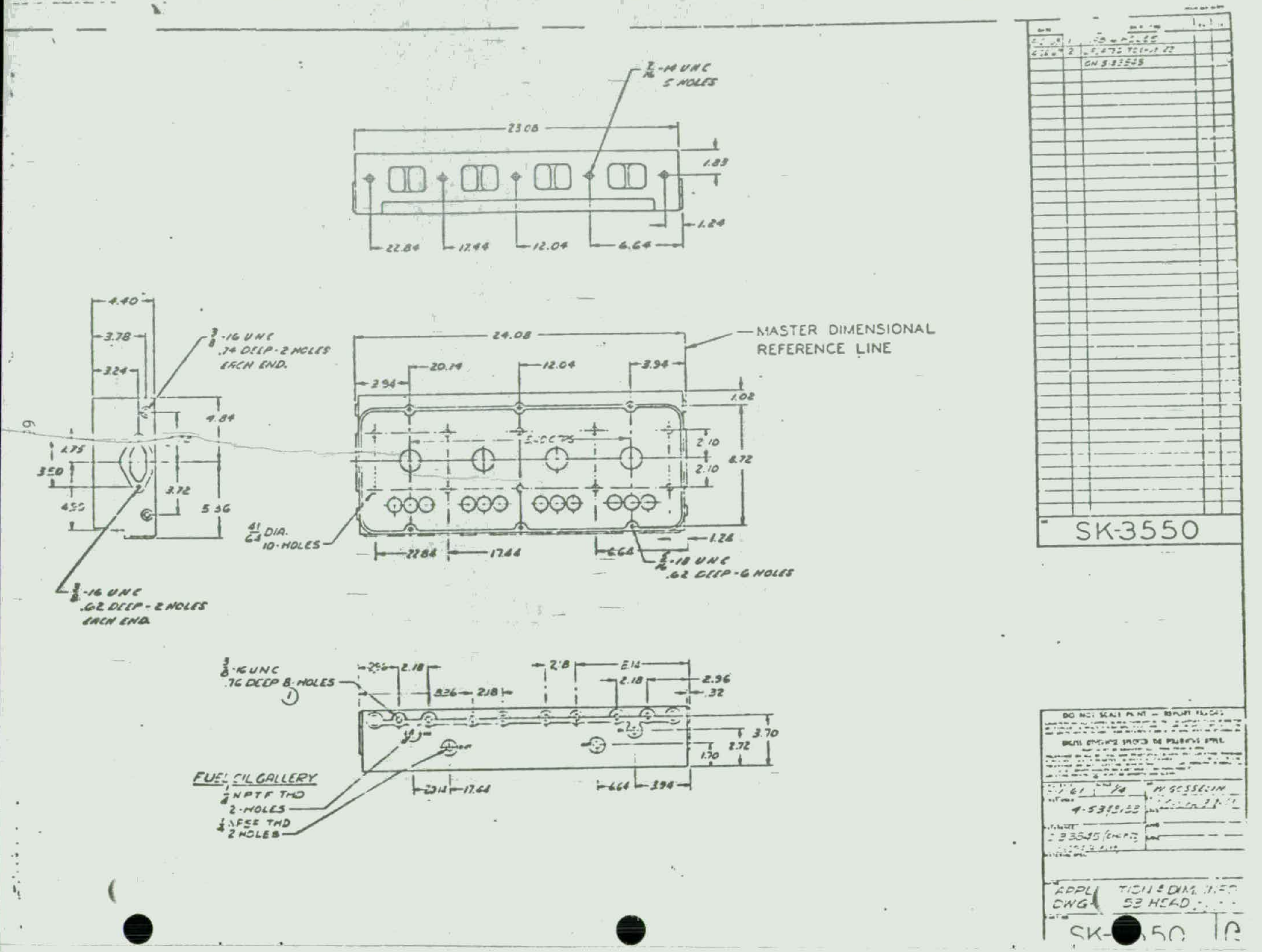


FOR COMPLETE DIMENSIONS REFER TO INST. DWG. 2SA314


2.50
℄ ENG.
℄ CRANKSHAFT

5100146
2


℄ ENG.
.12 DI
$\frac{3}{8}$-16 THD
FRONT
℄ CRANKSHAFT
4-53



23.08
1.83
1.24
22.84
17.44
12.04
6.64
24.08
20.14
12.04
3.94
2.94
1.02
2.10
2.10
8.72
4.40
3.78
3.24
4.84
3.72
5.56
$\frac{41}{64}$ DIA. 10-HOLES
1.24
MASTER DIMENSIONAL REFERENCE LINE
$\frac{3}{8}$-16 UNC .74 DEEP - 2 HOLES EACH END.
$\frac{3}{8}$-16 UNC .62 DEEP - 2 HOLES EACH END.
$\frac{5}{16}$-18 UNC .62 DEEP - 6 HOLES
$\frac{3}{8}$-16 UNC .76 DEEP 8-HOLES
2.18
2.96
.32
3.70
2.72
1.70
17.44
3.94
2 HOLES
SK-3550
DO NOT SCALE PRINT

PARTS LIST

DETROIT DIESEL ENGINE DIVISION
GENERAL MOTORS CORPORATION

NO. 06T00 1364 01

LINE	PART NO.	QTY.	CODE	PART NAME	REMARKS
1	5145617	1		COMPRESSOR AIR 12CFM ¤BW 283390	PA
2	5145014	6		PLUG PIPE3/8-18PTF SHTHEXSOC TEF	HOLES¤WAT¤/
3	5145009	1		PLUG PIPE1/8-27NPTFHEXSOC TEF	O/HOLE WHR REQ
4	5130964	1		PULLEY COMP 6.25 DIA 2 GROOVE	
5	103385	1		PIN COT 1/8X1	
6	5145594	1		BRACKET AIR COMP MTG	¤#
7	106337	6		BOLT 7/16-14X1 3/8 ¤COMP TJ	
8	103322	6		LW 7/16 ¤BRKT	
9	186622	4		BOLT 3/8-16X1 1/4 ¤BRKT	
10	5157244	1		BOLT 3/8-16X1 3/4 SPL ¤TJ	
11	103321	5		LW 3/8 ¤CYL BLK	
12	5131939	1		GASKET AIR COMP ¤TO COMP BASE	
13	5110411	1		STRAINER ASM AIR COMP	PA
14	5110410	1	R	GASKET AIR COMP	FURN WITH COMP
15	179827	2		BOLT 5/16-18X2 1/4	
16	103320	2		LW 5/16	
17	DED 5150023	1	D	COVER CYL BLK WAT HOLE PLN	IN 6A1
18	5115097	1		COVER CYL BLK WAT HOLE 3/8NPT	
19	DED 179816	2	D	BOLT 5/16-18X3/4 ¤CVR TO BLK	IN 6A1
20	186625	2		BOLT 5/16-18X7/8 ¤CVR TO BLK	
21	5109116	1		HOSE 1/2 X 10	
22	5120020	2		FITTING FEM SWIV 1/2 HOSE 3/4-16	
23	118757	2		EL 90 DEG 1/2 TUB 3/8 NPT ¤COMP FRT	
24	DED 5145014	1	D	PLUG PIPE3/8-18PTF SHTHEXSOC TEF	IN 6K38
25	5121810	1		HOSE 1/2 X 12 1/2	
26	5120020	1		FITTING FEM SWIV 1/2 HOSE 3/4-16 ¤IN	PA
27	118752	1		CONN 1/2 TUB 3/8 NPT ¤IN THERM HSG	PA
28	118757	1		EL 90 DEG 1/2 TUB 3/8 NPT	¤COMP¤
29	DED 5145009	1	D	PLUG PIPE1/8-27NPTFHEXSOC TEF	IN 6J
30	AAAA0105	1		HOSE ASM NO6 13.8IN A&A	
31	5100136	1		ADAPTOR 1/8 PIPE	COMP BRKT
32	187322	2		EL 90 DEG 3/8 TUB 1/8 NPT	
33	2488022	1		CLIP 3/8 NEOPRENE ¤LWR FRT	CVR BOLT
34	5163529	1		CLIP 5/16 DIA ¤TO LWR FRT CVR BOLT	
35	5118398	1		HOSE 5/8X10 ¤COMP BRKT TO OIL PAN	¤@
36	5113215	1		FITTING MALE 5/8 HOSE 1/2-14¤BRKT END	
37	DED 5145012	1	D	PLUG PIPE1/2-14HEXSOC TEF ¤OIL PAN	IN 6E
38	9402801	1		ELBOW 45 DEG 5/8 TUB 7/8-14 EXT ¤IN	OIL PAN
39	5113192	1		FITTING FEM SWIV 5/8 HOSE 7/8-14	TO 9402801
40	SK 3253	1	R	SKETCH INSTAL	
41					
42				SEE 6K1B FOR DRIV BELTS	L-08-234
43				/IN COMP WHERE REQ	
44				@USE 5134580 HOSE 5/8X16 WHEN	L-27-274(5)
45				6E-175 IS SPEC W/SUMP TO FRT	
46				#MOVE VOLT REG TO RR-MT TO SI OF BLK	
47				IMMEDIATELY AHEAD OF STARTER	

REVISIONS: REINSTATED

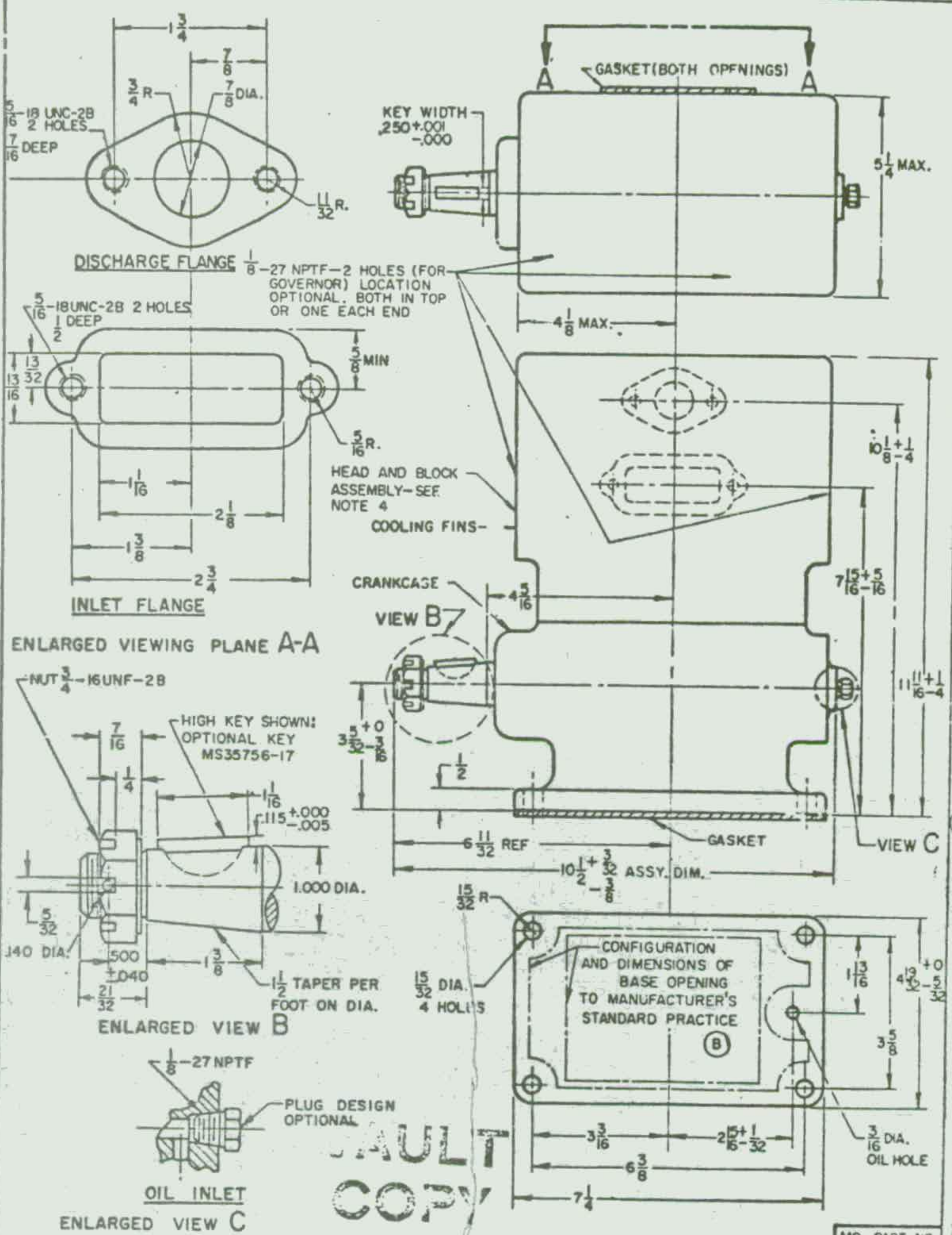
DISTRIBUTION 53-0 REF 6T-550

DESCRIPTION COMP 12 CR/SHF TRI DR RHSI STMP PAN 53

DATE ISSUED 05-08-73 DATE SUPERSEDED 07-05-72 SHEET 01 OF 0001 GROUP NO. 06T00 1364

DE 2400 EDP 205

FED. SUP CLASS 2530



VAULT COPY

(B) FOR CHANGES SEE SHEETS 1 AND 2

REVIEW ACTIVITY: AF-85 • USER ACTIVITIES: ARMY-ME; NAVY-MC, YD

This military standard is mandatory for use by all Departments and Agencies of the Department of Defense. Selection for all new engineering and design applications and for repetitive use shall be made from this document.

APPROVED 12 SEPT 1962 REVISED (A) 5 APRIL 1967 (B) 25 MARCH 1968

P.A. ARMY—AT Other Cust AF—84	TITLE COMPRESSOR, RECIPROCATING, POWER DRIVEN: AIR COOLED, 12 C.F.M. W/ UNLOADER	MS PART NO. MS 53032-1 MILITARY STANDARD MS 53032
PROCUREMENT SPECIFICATION MIL-C-45334	SUPERSEDES	SHEET 1 OF 2

DD FORM 1 SEP 67 672-1 (Continued) PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

FED. SUP CLASS 2530

(B)

NOTES:

1. THIS COMPRESSOR SHALL CONFORM TO MIL-C-45334, TYPE II.
2. RECOMMENDED MAXIMUM OPERATING SPEED 2400 RPM.
3. MAXIMUM BUILD-UP TIME TO PUMP A 1000 CU. IN. RESERVOIR TO 100 PSIG:
   21 SECONDS - AT COMPRESSOR SPEED OF 2400 RPM.
   33 SECONDS - AT COMPRESSOR SPEED OF 1200 RPM.
4. COMPRESSOR SHALL BE CONSTRUCTED TO ALLOW 180° ROTATION OF THE HEAD AND BLOCK ASSEMBLY TO PROVIDE FOR RIGHT OR LEFT LOCATION OF THE INLET AND DISCHARGE FLANGES. MANUFACTURER SHALL FURNISH AN INSTRUCTION SHEET, TOGETHER WITH A SPARE GASKET FOR EACH COMPRESSOR.
5. MAXIMUM WEIGHT: 37 POUNDS.
6. DIMENSIONS ARE IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE ± 1/64 ON FRACTIONS, ±.035 ON DECIMALS, ± 1° ON ANGLES, ± 1/16 ON CASTINGS.
7. THREADS SHALL BE IN ACCORDANCE WITH SCREW THREAD STANDARDS FOR FEDERAL SERVICES HANDBOOK H28.
8. THIS STANDARD IS NOT INTENDED TO LIMIT CONSTRUCTION TO FEATURES OTHER THAN AS SHOWN HEREON, BY DIMENSIONS, NOTATIONS, OR REFERENCED DOCUMENTS.
9. REFERENCED DOCUMENTS SHALL BE OF THE ISSUE IN EFFECT ON DATE OF INVITATIONS FOR BID.
10. FOR DESIGN FEATURE PURPOSES, THIS STANDARD TAKES PRECEDENCE OVER PROCUREMENT DOCUMENTS REFERENCED HEREIN.
11. MARKING SHALL CONSIST OF THE MS PART NUMBER, MANUFACTURER'S IDENTIFICATION AND SERIAL NUMBER IN ACCORDANCE WITH MIL-STD-130.

APPROVED 12 SEPT 1962 REVISED (A) FOR CHANGES SEE SHEETS 1 AND 2 (B) FOR CHANGES SEE SHEETS 1 AND

This military standard is mandatory for use by all Departments and Agencies of the Department of Defense. Selection for all new engineering and design applications and for repetitive use shall be made from this document.

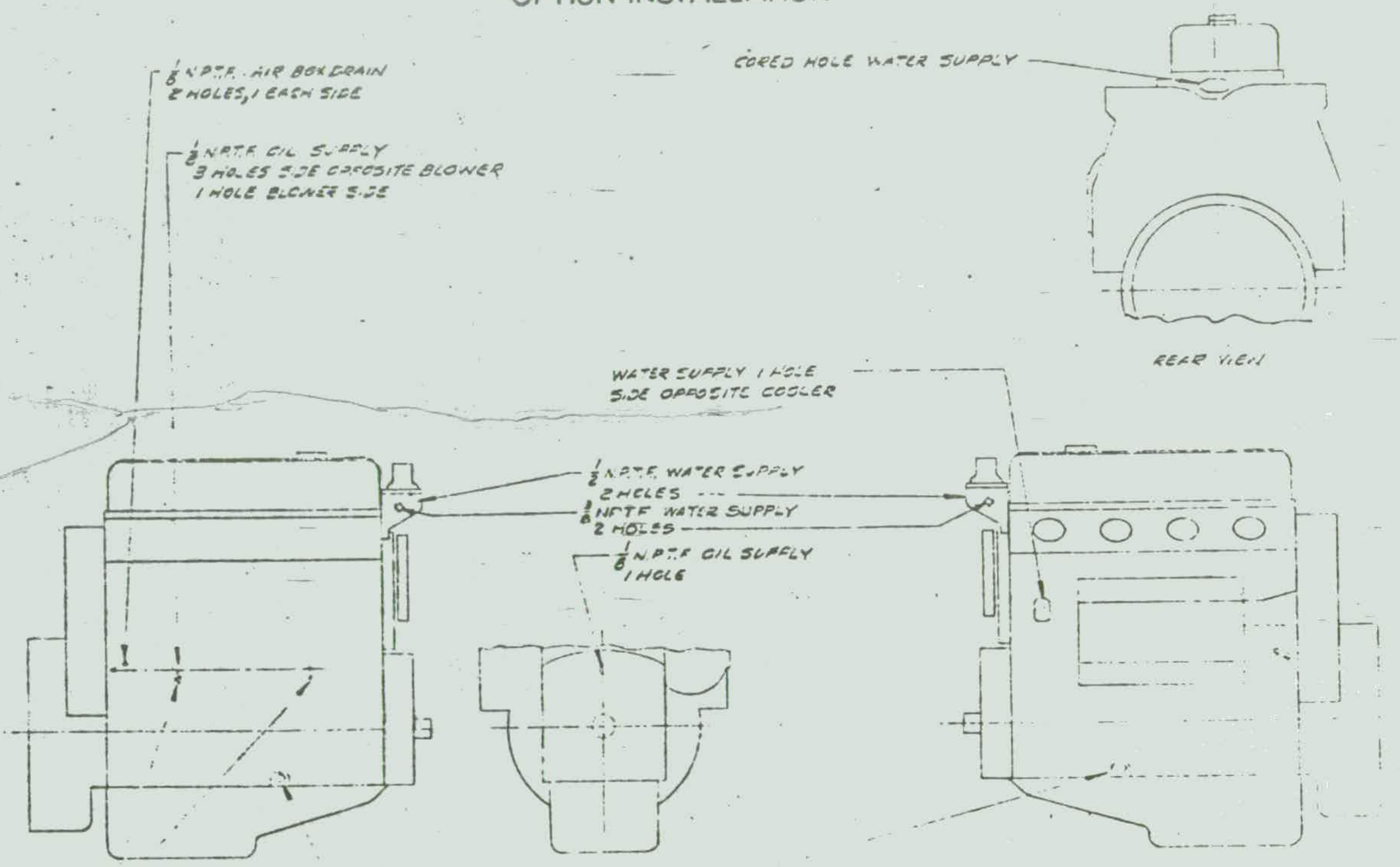
P.A. ARMY-AT Other Cust AF-84	TITLE COMPRESSOR, RECIPROCATING, POWER DRIVEN: AIR COOLED, 12 C.F.M. W/UNLOADER	MILITARY STANDARD MS53032
PROCUREMENT SPECIFICATION MIL-C-45334	SUPERSEDES	SHEET 2

DD FORM 672-1 COORDINATED

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE

☆ U. S. GOVERNMENT PRINTING OFFICE: 1968-301-519/5477

— OPTION INSTALLATION —

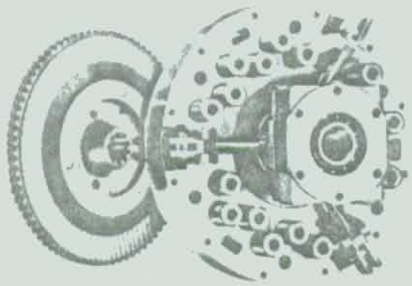


GROUP NO.	DESCRIPTION		DRWG. NO.
035	[illegible] AND OIL [illegible]	[illegible]	[illegible]
	DRAWN BY [illegible]	DATE [illegible]	

Rockford Clutches • Power Take-Offs • Gear Reduction Units • Torque Converters

mechanical • hydraulic

NEW! HEAVY DUTY PULL-TYPE, FULL OIL-FLOW CLUTCHES

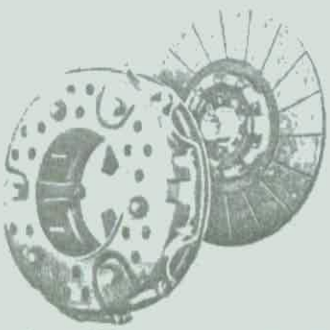


These full oil flow wet clutches deliver top performance in motor trucks and as part of the drive lines for other heavy duty automotive equipment. Handle range of engine sizes from 300 to 1100 lbs.-ft. Long life and exceptional dependability are due to full oil flow continuously pumped by internal-external gear pump to all friction surfaces of the plates. Included are integral oil pump, output shaft brake and 2, 3, or 4 plates depending on torque outputs. Compact clutch, brake, pump and sump are in one housing. Remote sump available when required.

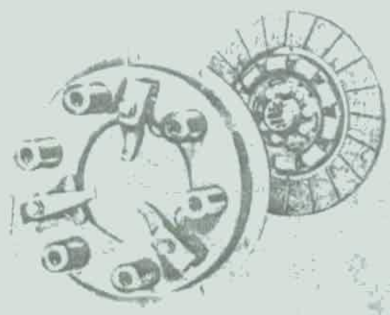
NEW OIL spring loaded clutch

NEW OIL over center clutch

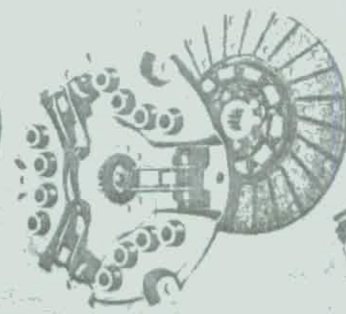
MOST ROCKFORD SPRING LOADED CLUTCHES MAY BE HAD WITH OUR VIBRATION DAMPENER FEATURE



Model RT Single plate, dry, for flat flywheel. Sizes 11, 12, 13, 14 in.; for counterbored flywheel in 14 and 15 in. sizes. Multiple plate available.



Model RM 6½, 8, 8½, 9, 10, 11 in. dia. Available with flat cover plate for use with counterbored flywheel; some sizes available with cupped cover plate for use with flat flywheel.



Model FA Wet or dry operation. With or without dual drive design for constant-running auxiliary drive, with PTO splined hub.

Model TS Single plate, dry; 5½, 6, 6½ in.; 50 to 75 ft. lb. max capacity. Used in midget cars and trucks, small garden tractors, and auxiliary drives in industrial trucks.

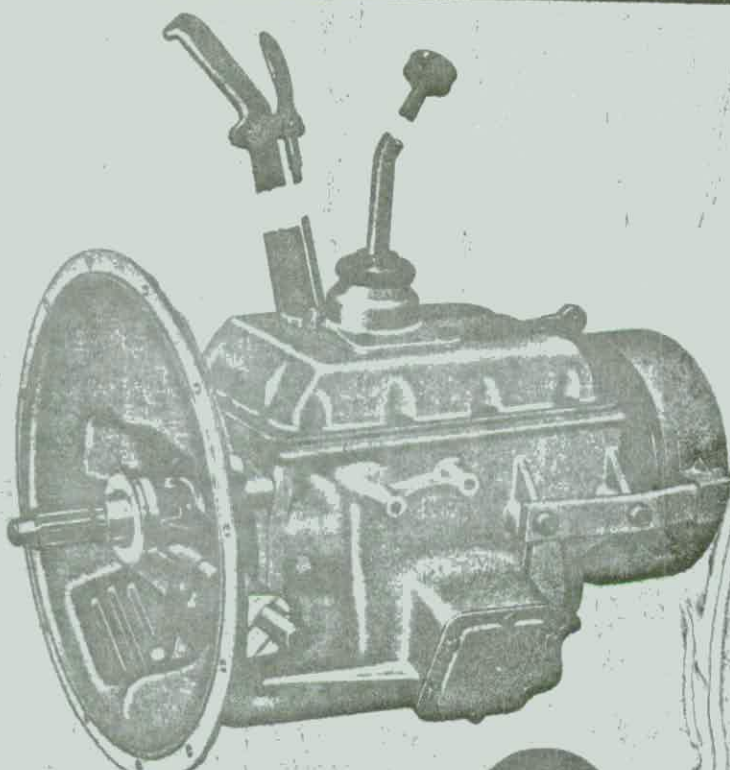
These partial specifications represent only a few of the available sizes

CLUTCH		TORQUE CAPACITY	BELL HOUSING MIN. SIZE S.A.E. NO.	CLUTCH WEIGHT	OUTSIDE DIA. OF CLUTCH	CLUTCH MOUNTING BOLT CIRCLE
PULL TYPE FULL OIL FLOW	2 PLATE	400-800 FT. LBS.	2	74.7 LBS.	14.997	14.250
	3 PLATE	600-1200 FT. LBS.	2	84.0 LBS.	14.997	14.250
	4 PLATE	1000-1600 FT. LBS.	2	94.6 LBS.	14.997	14.250
11″ RT		320 FT. LBS.	4	26 LBS.	13.000	12.377 12.373
12″ RT		430 FT. LBS.	3	31 LBS.	14.690	13.502 13.498
13″ RT		520 FT. LBS.	3	48 LBS.	15.380	14.630 14.620
14″ RT		600 FT. LBS.	2	66 LBS.	16.250	15.505 15.494
15″ RT		950 FT. LBS.	2	76 LBS.	16.628 16.625	15.88
11″ FA		380-530 FT. LBS.	4	28 LBS.	12.436 12.433	11.750
12″ FA		480-770 FT. LBS.	4	38 LBS.	13.999 13.996	13.000
14″ FA		600-960 FT. LBS.	3	54 LBS.	15.502 15.499	14.750

Division of Borg-Warner Corporation

ROCKFORD CLUTCH BORG WARNER®

MODEL 280V



Features

- 5 speeds forward, 1 reverse
- Clark-designed split pin synchronizers
- positive spline locks
- high speed P.T.O.
- six available ratios
- extra capacity synchronizers
- constant mesh gears in 4 top speeds
- wide gear faces

Options

- brake equipment
- shift lever to suit requirements
- mechanical remote control
- bell housing—S.A.E. No. 2 or No. 3

A new modern design transmission with greater torque output capability to handle bigger engines and increased GCW loads, the Clark 280V series of synchronized transmissions incorporates the latest innovations in engineering design, materials specification and manufacturing techniques. These include: Clark designed split-pin synchronizers; positive spline locks to prevent gear popout; and wide gear faces to provide conservative gear loads for increased transmission life.

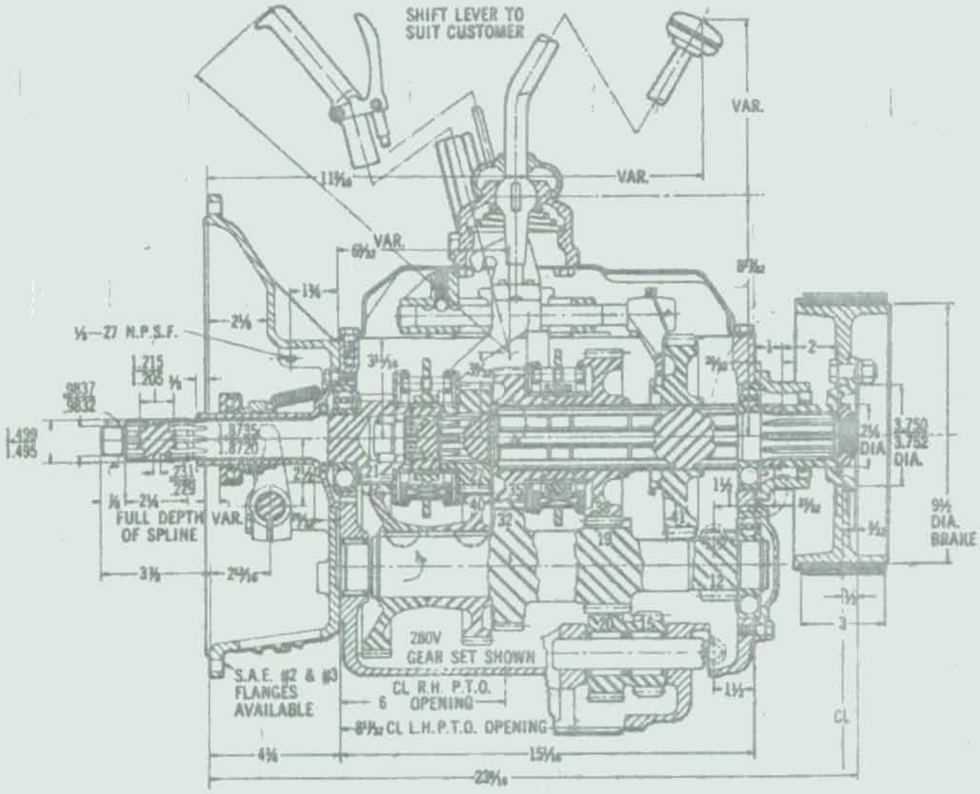
Tested and proved in dump trucks, transit mixers and car and freight haulers, the GTO-280 is designed for use with engines in the 280-350 lb. ft. torque range.

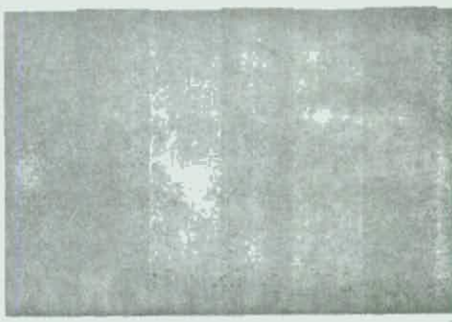
See reverse side for specifications. Phone, write or wire for additional information pertinent to your application.

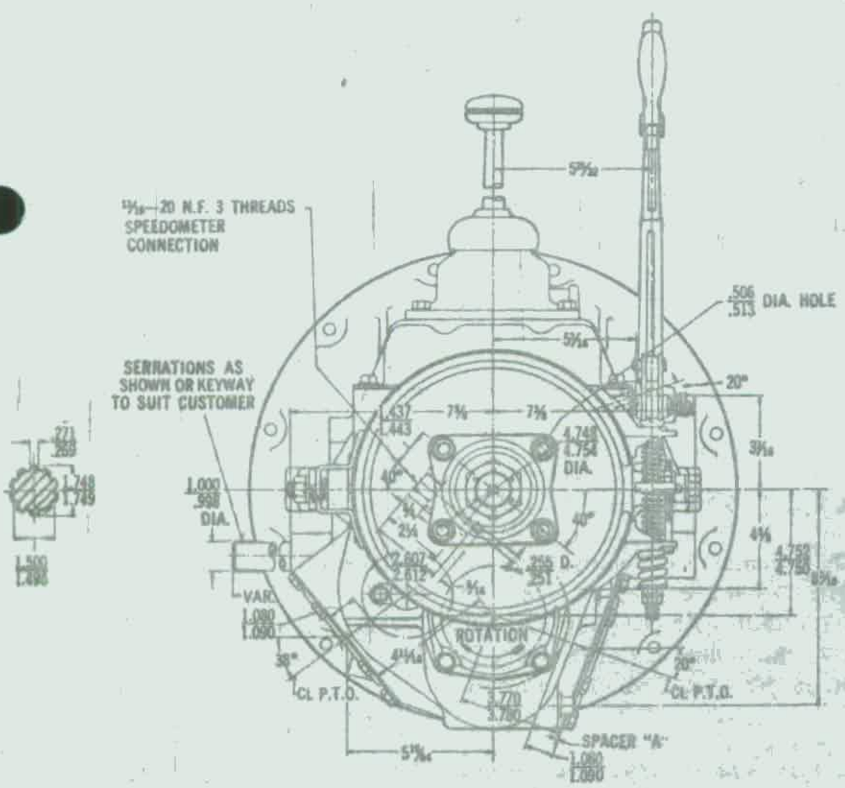
THE CLARK SPLIT PIN SYNCHRONIZER... It synchronizes transmission gears to the speed of the vehicle... smooths up-or-down shifting... prevents gear clash ...makes shifts much easier. Results include longer life for heavy duty transmissions, less driver fatigue, reduced driving time.

CLARK EQUIPMENT

CLARK EQUIPMENT COMPANY
AUTOMOTIVE DIVISION
Jackson, Michigan (517) 764-6000







MODEL 280V

NORMAL TORQUE RANGE: 280-350 Lbs. Ft.

Control: Furnished with Center Control and Remote Control; remote control optional.

Speedometer Drive: Rear bearing cover is arranged for Stewart-Warner type speedometer gears.

Brake Equipment Available: Band brake 9½" dia. by 3" wide, with 3/16" lining. Hydraulic pressed and ground heavy duty lining with counter bores for all rivet heads used. Brake is cam operated with equalizing shoes.

Ratios:

GEAR RATIOS

SPEED	MODELS					
	280V	280VO	282V	285V	288V	289V
FIFTH	DIRECT	0.80:1	DIRECT	DIRECT	DIRECT	DIRECT
FOURTH	1.48:1	DIRECT	1.17:1	1.47:1	1.37:1	1.18:1
THIRD	2.40:1	1.86:1	2.17:1	2.24:1	1.91:1	1.91:1
SECOND	4.38:1	3.50:1	4.09:1	4.09:1	3.50:1	3.50:1
FIRST	7.48:1	5.98:1	6.99:1	6.99:1	5.98:1	5.98:1
REVERSE	6.30:1	5.04:1	5.89:1	5.89:1	5.04:1	5.04:1

Power Take-Off: Operates off countershaft fourth gear on the right side and off reverse idler on the left side to provide a desirable wide range of operating speeds. Note: No adaptor is required on either side.

Synchronizers: In second, third, fourth, and fifth gears Clark's split pin type synchronizer construction with greater effective cone diameters provides an increase in synchronizer braking capacity.

Bell Housing: S.A.E. No. 2 or No. 3 available.

Clutch Shaft End: 1½" dia. standard 10 spline.

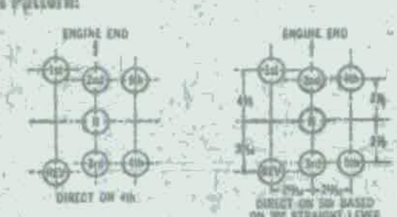
Clutch Installation: Arranged to suit standard makes.

Mainshaft End: 1¾" dia. S.A.E. 10 Spline.

Oil Capacity: 4 Quarts

Weight: Approximately 238 lbs.

Shift Pattern:

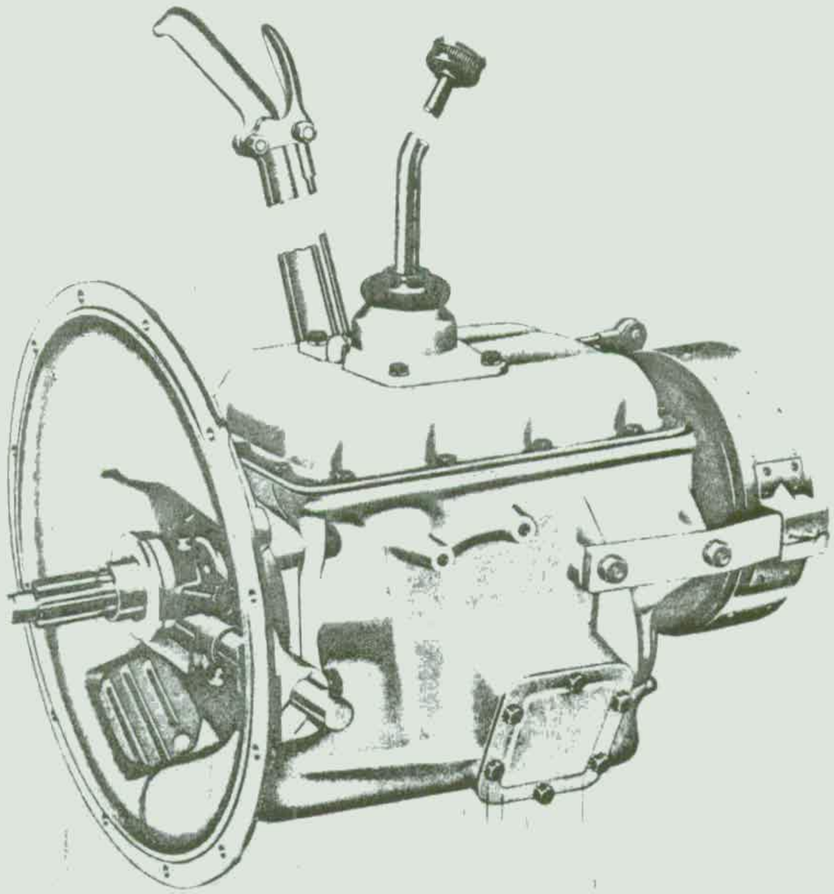


CLARK EQUIPMENT

AUTOMOTIVE DIVISION

MODEL 280V

FIVE SPEED FORWARD
AND ONE REVERSE



GENERAL SPECIFICATIONS

GEARS—Quiet constant mesh gears for the four top speeds.
SYNCHRONIZED—In 2nd, 3rd, 4th, and 5th Speeds.
NOMINAL TORQUE RANGE—280-350 LBS. FT.
WEIGHT—275 lbs. with brake as shown.
CLUTCH HOUSING—S.A.E. No. 2 and No. 3.

SPECIFICATIONS AND/OR DESIGNS ARE SUBJECT TO CHANGE WITHOUT NOTICE OR OBLIGATION

FOR ATLAS USE REMOTE SHIFT
LEVER 230729
REMOTE CONTROL 21613

CLARK EQUIPMENT COMPANY

JACKSON - - MICHIGAN, U.S.A.

CLARK EQUIPMENT

PTO DATA RIGHT SIDE

MODEL	DRIVING GEAR 7/9 PITCH 19°51'46" PA* 23°12'57" HA(RH)	SPEED AT 1000 RPM OF ENGINE	SPACER "A"
280V	40T	456 RPM	131
280VO	46T	571 RPM	560
282V	42T	489 RPM	332
285V	39T	489 RPM	060
288V	37T	571 RPM	000
289V	40T	571 RPM	131

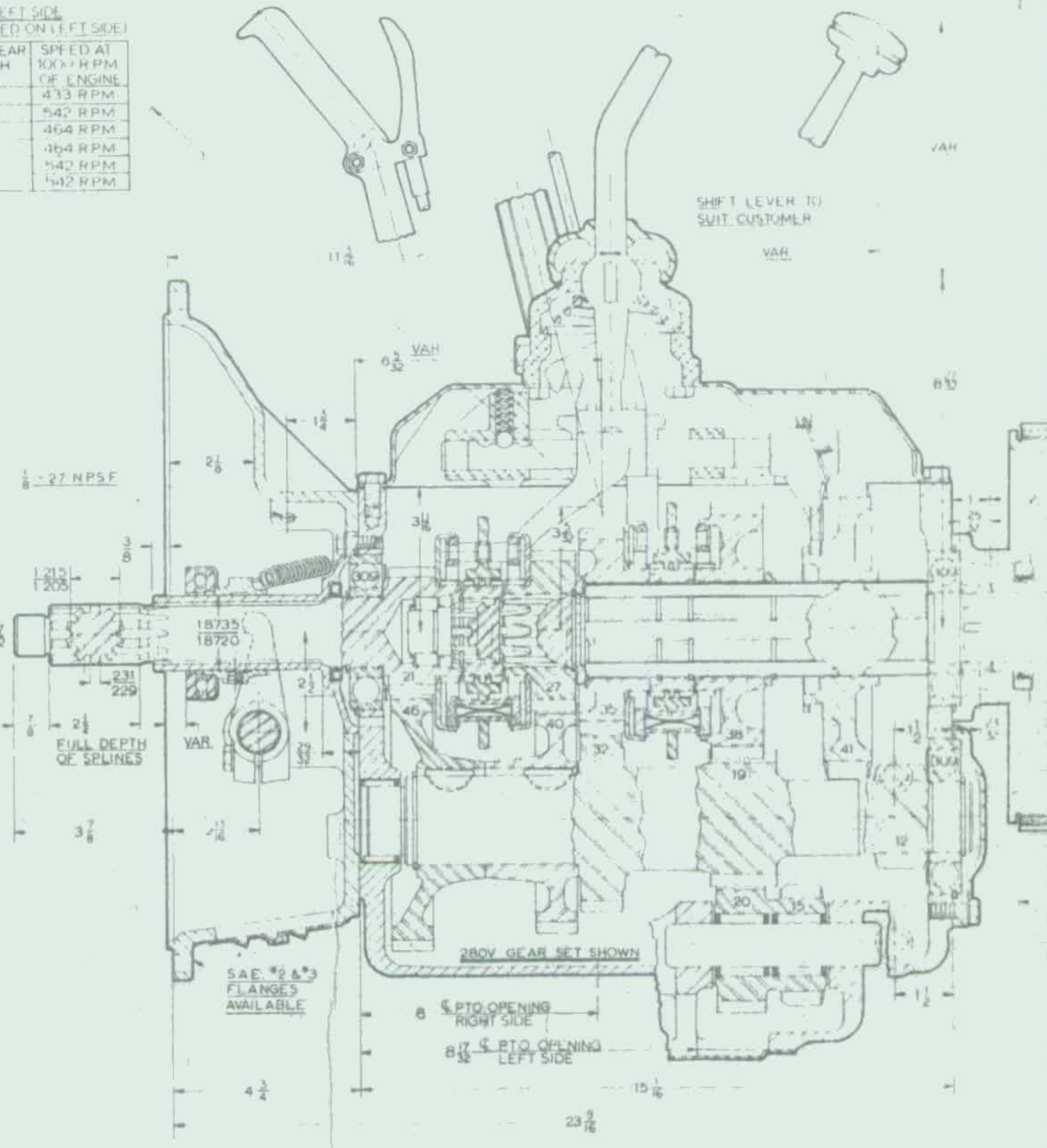
*PLANE OF ROTATION

PTO DATA-LEFT SIDE
(NO SPACER REQUIRED ON LEFT SIDE)

MODEL	DRIVING GEAR 6/8 PITCH 20° PA	SPEED AT 1000 RPM OF ENGINE
280V	20T	433 RPM
280VO	20T	542 RPM
282V	20T	464 RPM
285V	20T	464 RPM
288V	20T	542 RPM
289V	20T	542 RPM

GEAR RATIOS

SPEED	MODELS					
	280V	280VO	282V	285V	288V	289V
FIFTH	DIRECT	0.801	DIRECT	DIRECT	DIRECT	DIRECT
FOURTH	1481	DIRECT	1171	1471	1371	1181
THIRD	2401	1861	2171	2241	1911	1911
SECOND	4381	3501	4091	4091	3501	3501
FIRST	7481	5981	6991	6991	5981	5981
REVERSE	6301	5041	5891	5891	5041	5041



CLARK EQUIPMENT

280-350 LBS. FT. NOMINAL TORQUE RANGE—When desired, our engineers will give the definite torque rating for these units upon receipt of complete data as requested on our standard specification sheets. We cannot assume responsibility for installations which have not been approved by our Engineering Department.

BELL HOUSING—S.A.E. No. 2 and No. 3

CLUTCH SHAFT END—1½" Dia. Std. 10 Spline.

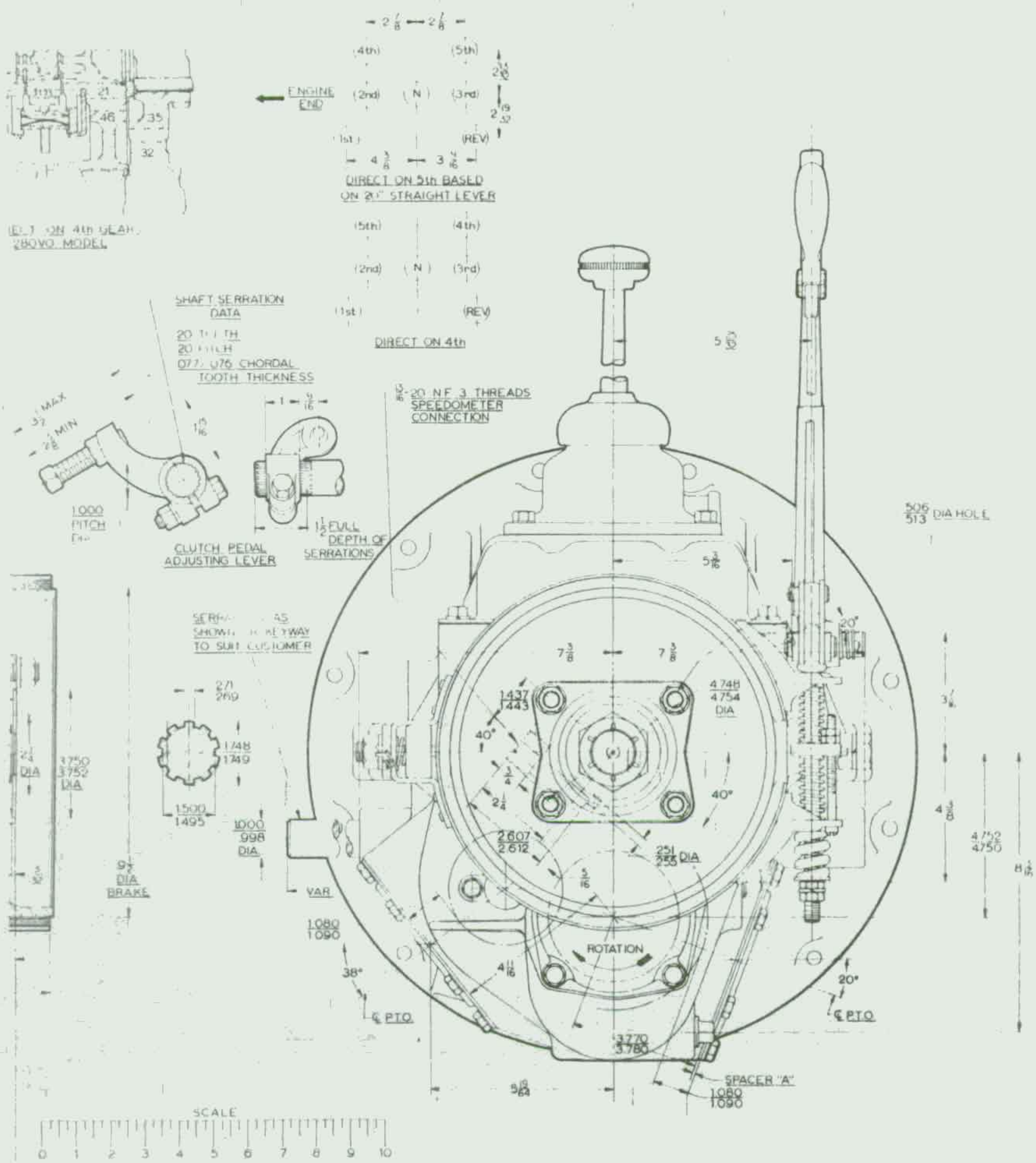
CLUTCH INSTALLATION—Arranged to suit Standard makes.

MAINSHAFT END—1¾" Dia. S.A.E. 10 Spline.

MATERIAL—Gears and mainshaft made of Alloy steel carburized. Made from fine grain, full upset forgings heat treated to obtain the maximum properties of the steel for clash, wear, distortion and strength.

CONTROLS—Furnished with Center Control Only.

SPEEDOMETER DRIVE—Rear Bearing Cover is arranged for Stewart-Warner type speedometer gears.



MODEL 280V

RAKE EQUIPMENT AVAILABLE—Band Brake 9½" Dia. x 3" wide, with 5/16" lining. Hydraulic pressed and ground heavy duty lining with counterbores for all rivet heads used. Brake is cam operated with equalizing shoes.

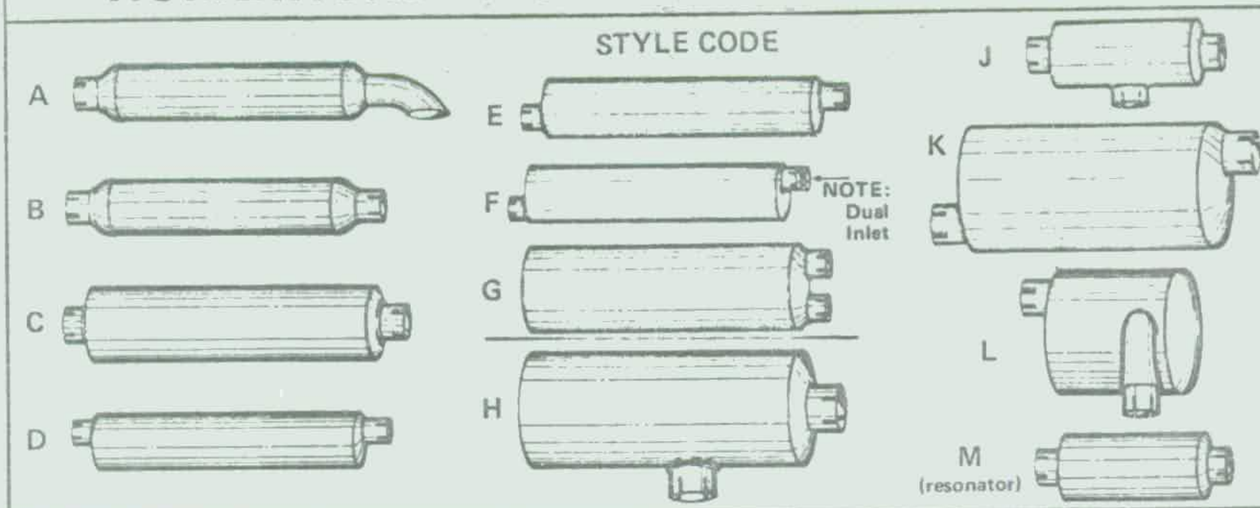
)IL CAPACITY—4 Quarts.

VEIGHT—238 lbs. with all equipment as shown (except brake). 37 lbs. 3" x 9½" brake, cast drum and flange.

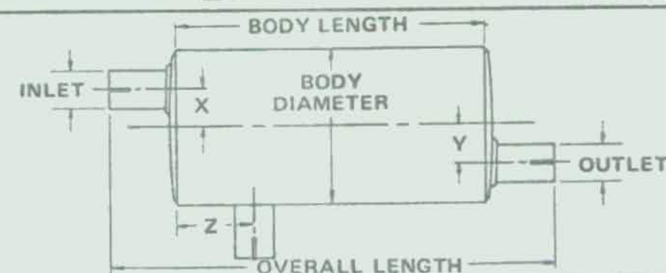
FOR RECOMMENDATIONS AND APPROVAL PLEASE FILL OUT SPECIFICATION SHEET PROVIDED.

NUMERICAL LISTING SPECIFICATION

STYLE CODE



– DIMENSION CODE –
(All Dimensions in Inches)



MUFFLER NO.	STYLE	INLET ID Notched Except Noted	BODY DIA.	BODY LENGTH	OUTLET ID Notched Except Noted	OVERALL LENGTH	X Inlet Distance Off-Center	Y Outlet Distance Off-center	Z Distance From Body Edge
201	A	2	6	14½	2 Spout	30½			
202	A	2¼	6	14½	2 Spout	30½			
204	A	2½	6	22½	2½ Spout	39½			
205	A	2¾	6	22½	2½ Spout	39½			
206	A	3	6	22½	3 Spout	40 1/8			
207	A	3½	6	22½	3 Spout	39 7/8			
209	A	3¼	6	22½	3 Spout	40			
212	A	2½	6	28½	2½ Spout	45½			
401	B	2	6	14½	2	28½			
404	B	2½	6	22½	2½	36½			
406	B	3	6	22½	3	36½			
407	B	3½	6	32¾	3	46¼			
408	B	4	6	32¾	4	45¾			
409	B	3¼	6	22½	3	36 1/8			
9004	C	2½	6	24	2½	30			
9006	E	2	6	24	2	30	1½	1½	
9007	E	2½	6	28½	2½	34¾	1¼	1¼	
9008	E	2½	6	28½	2	36¼	1¼	1¼	
9012	E	2½	6	22½	2	28¼	-0-	1½	
9013	C	3	6	24	3	30			
9016	C	2	6	19½	1¾	23½			
9017	E	2	6	19½	2	26	1½	1½	
9018	E	2½	6	24	2¼	29	1¼	1¼	
9022	E	2	6	28½	2	33	1½	1½	
9027	C	2	5	22½	2	28			
9051	C	2¼	5	34	2	40			
9100	C	2½	7	30	2½	36			
9103	C	3	7	32	3	39			
9105	C	3½	7	32½	3½	38			
9111	E	2¾	7	30	2¼	36	1½	1¾	
9113	E	3¼	7	23½	3	29	1¼	1½	
9121	M	3	7	12	3	20			
9122	M	3½	7	12	3½	20			
9123	M	4	7	12	4	20			
9125	C	3½	7	27	3	32½			
9127	E	3¼	7	26	2½	32	1¼	1¾	
9129	C	4	7	32½	4	39			
9131	E	2½	7	28½	2½	34¾	-0-	1¾	
9134	J	2 - 3	7	15	4	20			7½
9135	C	3 S.P.T.	7	14	3 S.P.T.	19¾			
9136	F	2-2½	7	28½	2½	34½	1¾	1¾	
9146	C	3½ S.P.T.	7	19	3½ S.P.T.	25½			
9147	C	4	7	38½	4	48			
9201	C	4	8½	48	4	54½			
9202	C	4	8½	33	3.84 OD	39			
9203	E	4	8½	42	3½ OD	47½	-0-	1¾	
9204	E	4	8½	33	3.84 OD	41	-0-	1 7/8	
9205	E	2¾ Flared	8½	36	2½	40	2	2¼	
9206	E	3	8½	20½	2½	28	2	2¼	

STEMCO MANUFACTURING COMPANY INC. A SUBSIDIARY OF Garlock

NUMERICAL LISTING SPECIFICATION

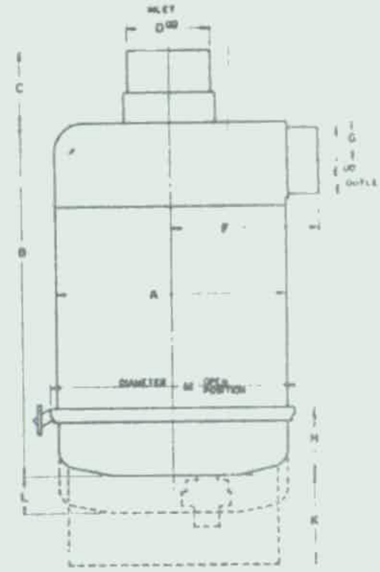
MUFFLER NO.	STYLE	INLET ID Notched Except Noted	BODY DIA.	BODY LENGTH	OUTLET ID Notched Except Noted	OVERALL LENGTH	X Inlet Distance Off-Center	Y Outlet Distance Off-center	Z Distance From Body Edge
9207	E	3½	8½	36	3	43	1¾	1¾	
9208	E	3	8½	30	3	36¼	2	2	
9210	E	3	8½	28	2.84 OD	34	2	2⅛	
9213	E	3½	8½	33	3.84 OD	40	1¾	1⅞	
9217	C	4	8½	42	3⅝ OD Hump	48¾			
9218	G	3	8½	28	3	32	2	2	
9225	E	4	8½	44	3.84 OD	52	-0-	1⅞	
9229	C	4 Flared	8½	42	3⅝ OD Hump	48¾			
9232	H	4	8½	48	4	51¼			33
9300	C	4	9	44	4	51			
9302	E	4	9	15	4	22	2	2	
9303	M	4	9	15	4	22			
9305	C	4	9	28	4	34½			
9306	C	4	9	40	4	48			
9310	M	5	9	12	5	20			
9315	C	3½	9	25	3½	31			
9321	E	5	9	40	5	48	1⅜	-0-	
9327	C	5	9	44	5	51			
9330	C	3½	9	48	5 OD	92			
9333	C	4 S.P.T.	9	20	4 S.P.T.	26			
9336	C	4	9	44	4	51			
9337	C	5	9	44	5	51			
9338	C	4	9	44	4	51			
9340	C	3½	9	44	3½	51			
9341	C	3½	9	44	3½	51			
9344	E	4	9	44	4	51	2	2	
9345	C	3½	9	36	3½	43			
9348	C	4	9	44	4	51			
9349	C	4	9	44	4	51			
9350	C	4	9	44	4	51			
9400	K	4	10x15	26	4	32½	4½	4½	
9401	K	5	10x15	26	4	32½	3⅛	3⅛	
9408	H	5	10x15	16	5	20½		1½	4
9412	H	4	10x15	16	5	20½	4½		3½
9413	H	4	10x15	21½	4	24½	4½		14½
9414	H	5	10x15	21½	4	24½	3½		14½
9416	G	4	10x15	39	5	42½	3	3	
9500	K	3½	8¼x11½	32	4	39	2½	2½	
9505	K	4	8¼x11½	28½	3.34 OD	36½	2¼	2¼	
9509	G	3½	8¼x11½	20	4	23½	3	3	
9510	G	4	8¼x11½	39	3½	42	2⅝	2⅝	
9512	K	3 Flared	8¼x11½	18	3 OD	22¾	3⅜	2¼	
9513	G	3 Flared	8¼x11½	20	2½ OD	22½	2¼	2¾	
9514	D	4	8¼x11½	40	4	46	2⅝	2⅝	
9515	H	4	8¼x11½	16	4	21½		2½	3¼
9523	K	4	8¼x11½	30	3.84 OD	40	2⅝	2⅝	
9524	H	3½	8¼x11½	18	3½	21		2½	2¾
9525	H	2¾	8¼x11½	20	2¾	23½		2⅞	2⅜
9526	H	3½	8¼x11½	30¾	3½ Spout	38¼		1¼	15⅜
9601	F	2-2½ Flared	8½	36	3⅛ OD Hump	43¼	1½	2	
9604	F	2-2½	8	30	3½ OD	37½	1¾	1½	
9605	F	2-2½ Flange	8	30	3½ OD	37½	1¾	1½	
9606	F	2-2½	8½	38	3⅛ OD	44¼	1½	2	
9607	F	2-2¾ Flared	8½	40	4	48¾	1½	1½	
9608	F	2-2½	8½	38	3	43¼	1½	2	
9700	E	2½	6½	27⅝	2½ OD	35½	1½	1½	
9701	D	2¾	6½	24	2½	29	1¼	1½	
9801	C	4	8	30	4	37			
9803	M	4	8	12	4	20			
9807	C	3½	8	30	3½	37			
9808	M	4	8	20	4	25¾			
9809	C	4	8	45	4	52			
98[illegible]7	E	4	8	30	4	36½	1⅝	1⅝	
985[illegible]	H	4	10	36	4	38½	-0-		3½
9853	E	4	10	28	4	33½	2⅛	2⅛	
9854	G	4	10	40½	4	43½	2¼	2¼	
9855	G	4	10	28	4	32	2¼	2¼	
9860	H	4	10	28	4	31½	2⅛		20½
9864	E	4	10	33	4	38½	2¼	2¼	
9866	E	4	10	44	4	51	2⅝	2⅝	
9876	G	4	12	26½	4	29½	2½	2½	
9877	G	6½ OD Flared	12	22	3 OD	25¼	2¼	3¾	
9901	L	4	10x15	12	4	16¼		4⅜	9
9905	L Special	4 Flared	10x15	26	3½ OD Hump	26	N/A	N/A	N/A
9906	L Special	4 Flared	10x15	23	3⅛ OD Hump	24		Special	N/A
9907	L Special	4 Flared	10x15	23	3⅛ OD Hump	23	N/A	N/A	N/A
9909	L Special	4 Flared	10x15	26	3½ OD Hump	26	N/A	N/A	
9913	L	4	10x15	12	4	16¼		4⅜	9
9915	L	4	10x15	12	4	16¼		4⅜	3
9917	L	4	10x15	12	4	16¼		4⅜	9
9918	L	4	10x15	16	3.84 OD	19½		4⅜	13
9926	L	4	10x15	16	3.84 OD	19½		4½	3
9930	L	5	10x15	16	4.84 OD	19½		4	3½
9938	L Special	4	10x15	12	4	12	N/A	N/A	3

CHROME PLATED COMPONENTS
EXHAUST SYSTEM COMPONENTS
ENGINE MAKE AND MODEL
TRUCK MAKE AND MODEL
SPECIFICATIONS BY INLET SIZE
OEM CROSS REFERENCE
NOISE REDUCTION TIPS
MUFFLERS TO MEET NOISE LEVELS

DONALDSON

SPECIFICATIONS

AIR CLEANERS



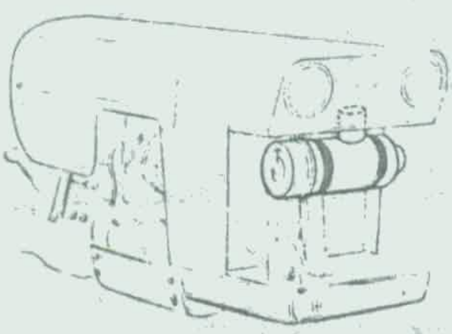
FWA and FWG cleaners can be mounted either horizontally or vertically.

Standard Air Cleaner Model	Vacuator Air Cleaner Model**	*Air Flow Rating At 8" H_2O Gas	At 12" H_2O Diesel	A	B	C	D	E	F	G	H	K	L	M	Approx. Wt. Lbs.
FWA05-2526	FWA05-2527	80	95	5¼	14 21/32	1⅞	2	2	4	1 3/16	3 3/16	8½	1⅜	6⅛	6
FWA06-5007	FWA06-5015	110	135	6½	17 3/32	2 1/16	2½	2¼	4¾	1 19/32	3¾	8 15/16	1⅜	7⅜	8
FWA08-0022	FWA08-0031	190	235	8	18 23/32	2 13/16	3	3	6 1/16*	2 3/16	3¾	9 13/16	1⅜	8⅞	10½
FWA10-0017	FWA10-0019	290	360	10 3/16	18½	4¾	3¾	4	7 3/16	2¼	4	7 5/32	1¼	11 3/16	20
FWA12-0003	FWA12-0036	350	440	11 13/16	18 17/32	3 27/32	4½	4	7 13/16	2½	4	7 3/32	1½	13⅝	24
FWA14-0002	FWA14-0036	460	530	14	21⅞	3 29/32	5	4	9	2 19/32	4	9 3/32	1½	15 13/16	33
FWA14-0003	FWA14-0033	560	700	14	21⅞	3 29/32	5	5½	9	3 3/32	4	9 3/32	1½	15 13/16	32
FWA16-0001	FWA16-0013	760	945	16	24½	4¼	6	6	10½	3¼	4	11 3/32	1½	17 13/16	52

*Ratings are ± 1" H_2O **Vacuator cup dimensions will vary slightly from Standard

Standard Air Cleaner Model	Vacuator Air Cleaner Model**	*Air Flow Rating At 8" H_2O Gas	At 12" H_2O Diesel	A	B	C	D	E	F	G	H	K	L	M	Approx. Wt. Lbs.
FWG04-2503	None	70	85	4⅜	9 11/16	1	1¾	1¾	3⅜	1½	3	5	1	5¼	3¼
FWG05-2510	FWG05-2512	95	115	5¼	12 1/32	1⅝	2	2	4*	1 1/16	3 1/32	8 17/32	1⅜	6⅛	4¾
FWG06-5008	FWG06-5012	140	170	6½	13 23/32	1 13/16	2½	2¼	4¾	1 1/16	3¾	8 15/16	1⅜	7⅜	6½
FWG08-0023	FWG08-0026	225	280	8	14 23/32	1 13/16	3	3	6 1/16	1¾	3¾	9¼	1⅜	8⅞	9½
FWG10-0003	FWG10-0004	330	405	10 3/16	16 1/32	1¾	4	4	7½	2 11/16	4	7 5/32	1¼	11 3/16	17
FWG12-0059	FWG12-0063	415	515	11 13/16	16 29/32	2 1/16	4½	4	7⅞	3¼	4	7 1/32	1½	13⅝	23
FWG14-0077	FWG14-0083	590	720	14	19 1/32	2 3/16	5	5½	9	3½	4	9 3/32	1½	15 13/16	32
FWG16-0104	FWG16-0107	870	1080	16	21 21/32	2 17/32	6	6	12	4	4	11 3/32	1½	17 13/16	45

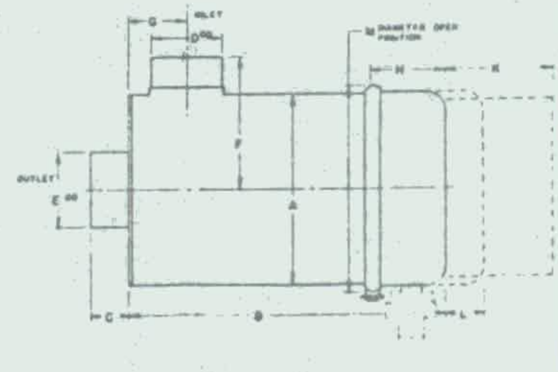
*Ratings are ± 1" H_2O **Vacuator cup dimensions will vary slightly from Standard



FWG CYCLOPAC installed horizontally on farm tractor.

D-1400 FILTER CLEANER
Detergent with carbon dissolving additive. Mix with water. Cleans any washable paper filter.

RESTRICTION GAUGE
Signal locks in view when filter element requires servicing. Mount on dash or cleaner.



NOTE: Dimensions not certified – Request prints for specific design applications.

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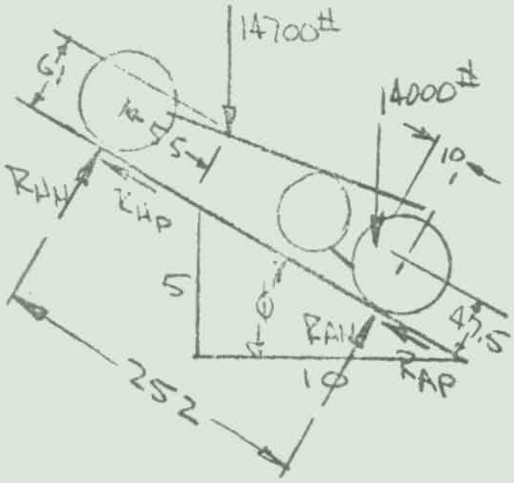
DRAWBAR PULL FOR CLIMBING
50% SLOPE
(BACKING UP)



$$R_{AN} = \frac{14700(\overset{53.5}{55\cos\phi} + \overset{27.7}{61\sin\phi}) + 14000(242\cos\phi + 47.5\sin\phi)}{252}$$

$$= 17030^{\#}$$

$$R_{HN} = \frac{14700(197\cos\phi - 61\sin\phi) + 14000(10\cos\phi - 47.5\sin\phi)}{252}$$

$$= 8020^{\#}$$

$R_{AP} = R_{AN}\tan\phi = 17030\,(.5) = 8515\,\#$

$R_{HP} = R_{AN}\tan\phi = 8020\,(.5) = 4010\,\#$

$\text{REQ'D DBP} = R_{AP} + R_{HP} + \frac{28700(17)}{1000} = 13015\,\#$

μ (BETWEEN TIRES & SLOPE) $= \frac{13015}{17030}$

$= .764$

THIS IS POSSIBLE ON A CLEAN SLOPE

DESIGN POWERTRAIN FOR 13500# DBP ⟵

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POWERTRAIN GEARING

1. 13500# DBP REQ'D FOR BACKING UP 50% SLOPE

2. TOP SPEED 35 - 40 MPH

1. TORQUE REQ'D = 13,500#(19.3 IN)

= 260,600 LB-IN

MAX TRANS RATIO IN REV. = 6.30:1

MAX ENG TORQUE = .85 x 252 LB-FT

AXLE-DROP BOX RATIO REQ'D

$$= \frac{260{,}600}{6.30(.85)(252)(12)} = 16.10$$

2. AXLE-DROP BOX RATIO FOR 35 MPH

$$= \frac{RPM_{GOV.}}{RPM_{WHEEL}} = \frac{RPM_{GOV}}{REV/MI \times \frac{MPH}{60}}$$

$$= \frac{2800 \times 60}{496 \times 35} = 9.68$$

AXLE RATIOS AVAILABLE ARE

8.2 & 7.8

SO TWO SPEED DROP BOX WILL BE NEEDED

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PAGE 2 OF
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WITH 8.2 AXLE

$$\text{MAX SPEED} = \frac{2800(60)}{496(8.2)} = 41.3$$

BETTER MAKE HIGH GEAR IN DROP BOX

$41.3/38 = 1.086$

LOW GEAR SHOULD BE ABOUT

$16.1/8.2 = 1.96$

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PAGE 1 OF

REPORT NO.

DRIVESHAFT AND U-JOINTS

MAX TORQUE = .85(259 LB-FT)(7.48)(1.984)
(TRANS) (DROPBOX)

= 3270 LB-FT

TIP DIFFERENTIAL AND USE SINGLE HOOKE JOINT AT THAT END OF DRIVESHAFT

USE CONSTANT VELOCITY JOINT AT TRANSFER CASE END WITH TRANSMISSION ANGLE OF 13°30' @ NOM STATIC SOLO

FOR THE SINGLE HOOKE JOINT A MECHANICS UNIVERSAL SIZE 7 IS SUITABLE - 3100 FT-LB MAX OPERATING TORQUE (ENDURANCE LIMIT, B10 LIFE 30,000 HRS)

THIS SHOULD BE MATCHED TO A MECHANICS CV DOUBLE CARDAN JOINT SIZE 7CV, 3100 FT-LB MAX OPERATING TORQUE

THESE ARE USED WITH 3½ OD X .098 WALL TUBE
MECHANICS LISTS A TORQUE CAPACITY OF 2550 LB-FT FOR A SHEAR STRESS OF 16,000 psi
THIS COMBINATION SHOULD BE MORE THAN ADEQUATE

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ACCESSORY DRIVES

FAN - AIR COMPRESSOR

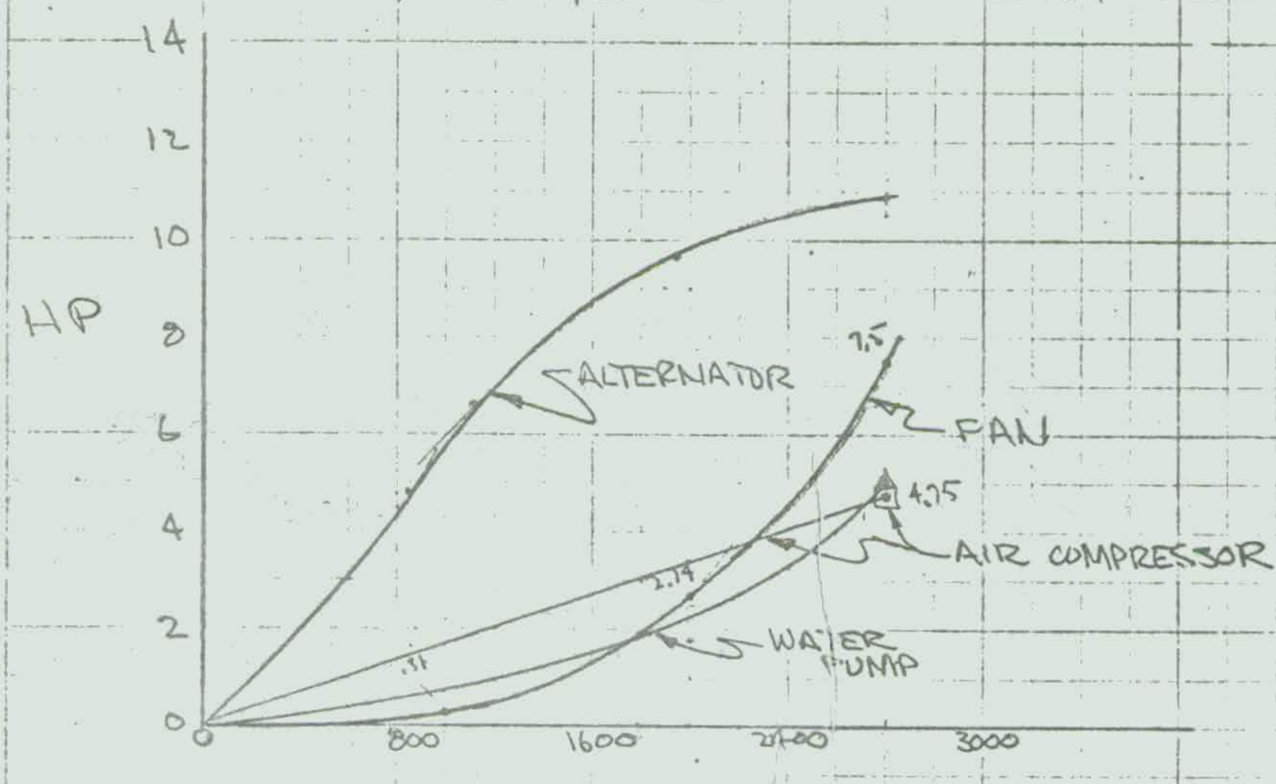
HP LOAD

FAN - (24 IN DIA - 6 BLADE)

7.5 HP @ 2850 RPM

AIR COMPRESSOR - MS - 12 CFM, 100 PSI

4.75 HP @ 2400 RPM



ALTERNATOR - WATER PUMP DRIVE

ALTERNATOR
4.8 HP @ 1500 (840 " ")
6.6 HP @ 2000 (1120 ENG RPM)
9.76 HP @ 3500 (1955 " ")
10.85 HP @ 5000 (2800 ENG RPM)

WATER PUMP

ASSUME 5 HP MAX

84

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PAGE 2 OF

REPORT NO.

LOAD-LIFE RELATIONS

FAN AND WATER PUMP RUN AT FULL LOAD ALL THE TIME

AIR COMPRESSOR RUNS AT FULL LOAD ON FOR SHORT BURSTS DURING OPERATION OF THE VEHICLE - IT MIGHT RUN AT FULL LOAD WHEN SUPPLYING POWER FOR OPERATING TOOLS (NO MORE THAN 5% OF LIFE)

ALTERNATOR WILL RUN ABOUT 5 AMPS NORMALLY WHEN LIGHTS ARE NOT IN USE, WITH LIGHTS IT WILL RUN ABOUT 30 AMPS, WHEN LIFTING THE HOWITZER TRAILS WITH THE ELECTRIC CRANE IT WILL RUN 84 AMPS (START) 70 AMPS (RUN) PICKING UP A 2000# LOAD. THE FULL CAPACITY OF 205 AMPS WILL BE USED ONLY WHEN THE ATLAS IS USED AS A GENERATOR SET (4900KVA).

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DUTY CYCLE FOR BELT DRIVE

VEHICLE DUTY CYCLE

A 5% AIR POWER SOURCE (2800 ENG RPM)
B 5% ELECTRIC GENERATOR (2800 ENG RPM)
C 5% OPERATING CRANE (1000 RPM)
D 5% ENGINE IDLE (600 RPM)
E 15% MAX ENGINE SPEED (2800 RPM)
F 35% NORMAL ROAD SPEED (2200 RPM)
G 20% CROSS COUNTRY (1800 RPM)
H 10% MANEUVERING (1200 RPM)

HP LOADS ON PULLEYS

	AIR COMP	FAN	CRANK	ALT	W. PUMP	CAM
A	4.75	7.5	12.25	6.5	.5	11.5
B	—	7.5	7.5	10.85	.5	15.9
C	3	1.5	3.5	3.8	1.8	4.6
D	1	.5	1.5	1.4	.5	1.9
E	1.2	7.5	8.7	1.6	5	6.6
F	.9	3.5	4.4	1.25	2.75	4.0
G	.75	1.8	2.6	1.0	1.8	2.8
H	.44	.5	.94	.5	.8	1.3

FOR A ASSUME ALTERNATOR PRODUCING 30 AMP
FOR E,F,G,H, ASSUME AIR COMPRESSOR AVE HP IS .25 X HP FROM CURVE, P.1 & ALTERNATOR USING 30 AMPS

Worksheet For Automotive Accessory Drives

(Use in conjunction with Design Manual 18575)

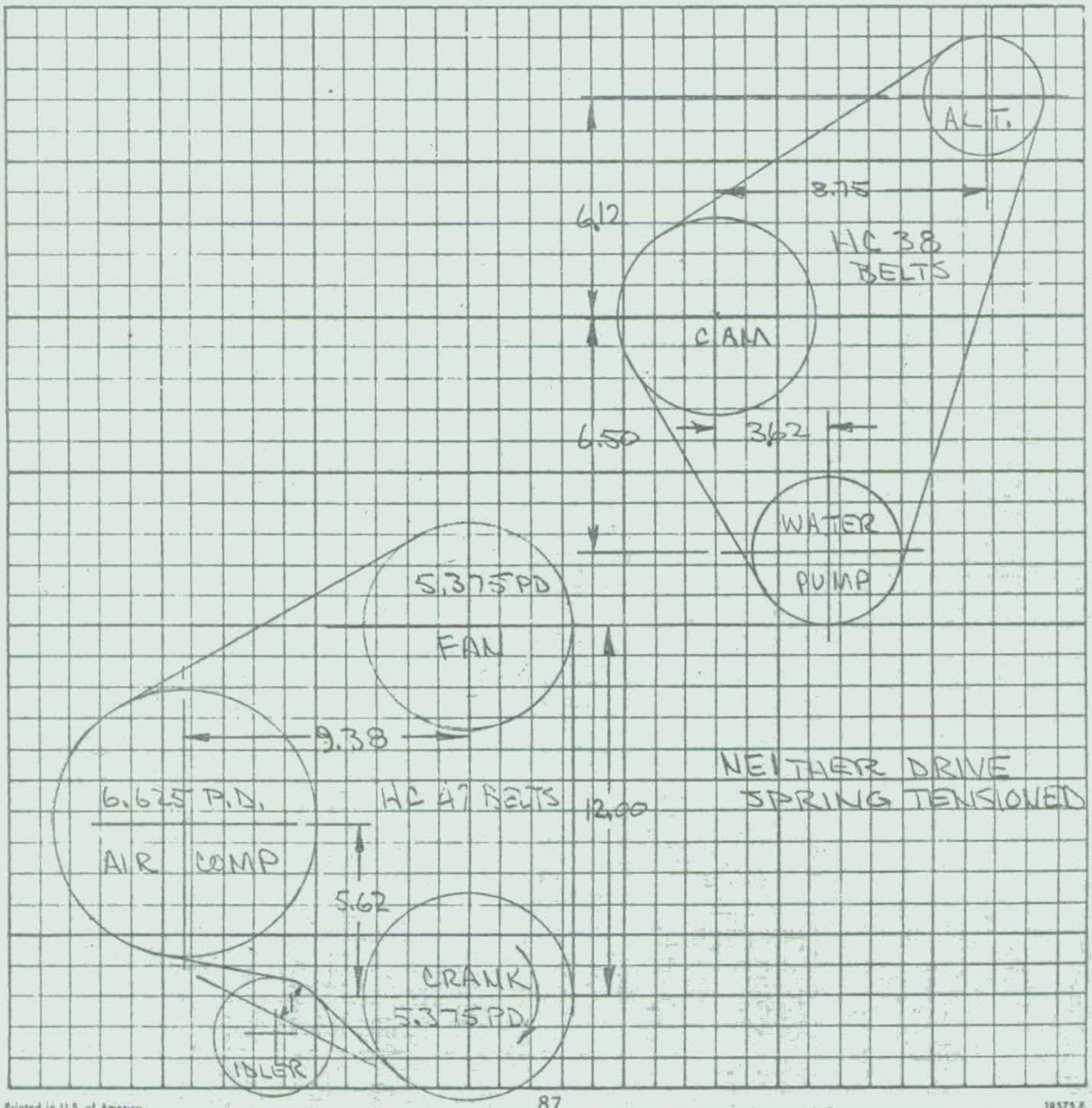
Sheet ______ of ______

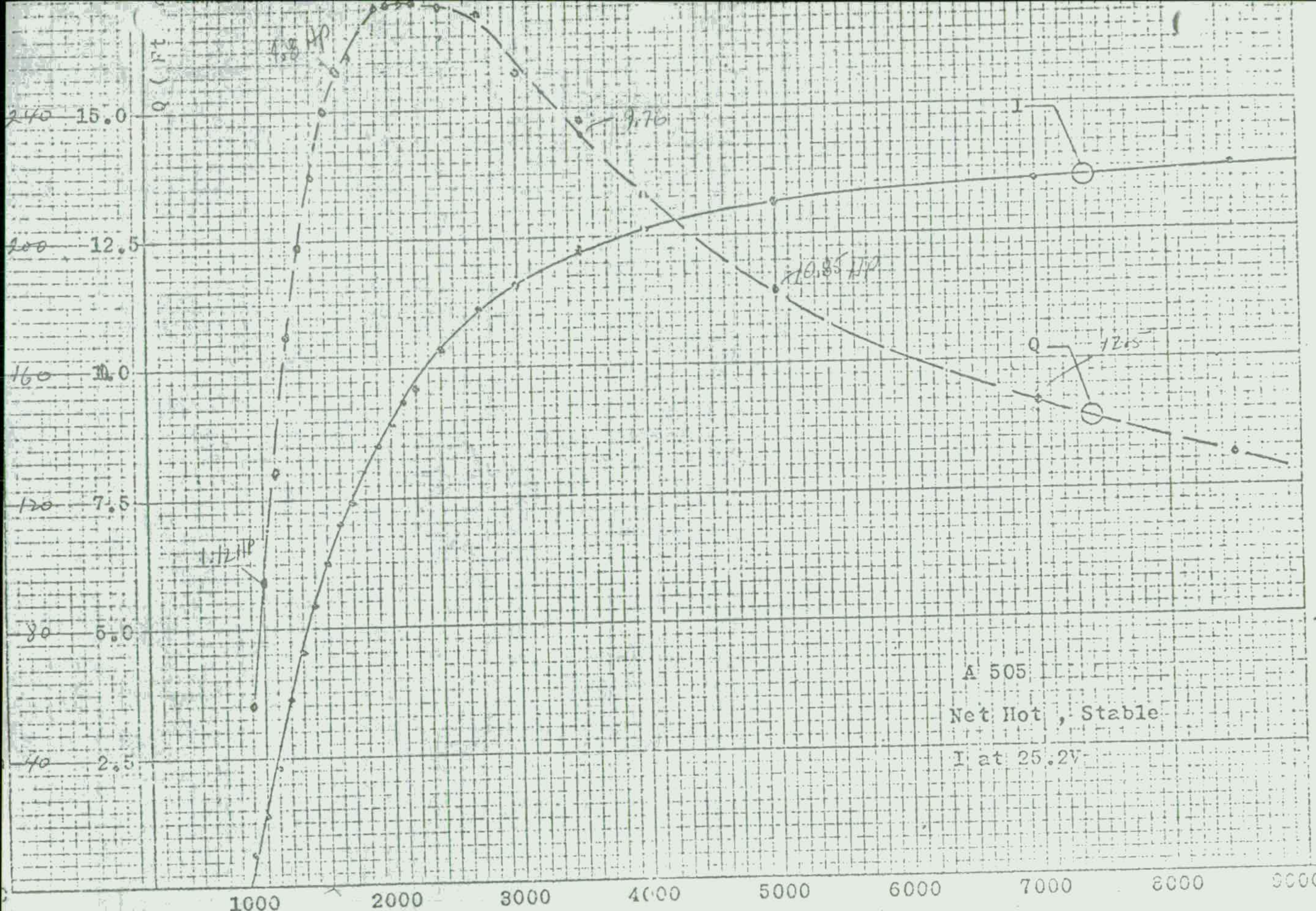
Company PACIFIC CAR & FOUNDRY Drive ATLAS ENGINE ACCESSORIES Date ______

Address ______ Model No. ______ Designed By ______

B. P. No. ______ Part No. ✓ (experimental) ______ (production)

Gates Prod. No. ______





88

ALTERNATOR RPM

NIEHOFF

3/6/72

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PAGE 11 OF

REPORT NO.

Reqd μ = $\frac{12.81}{17.605}$ = .727
for grade

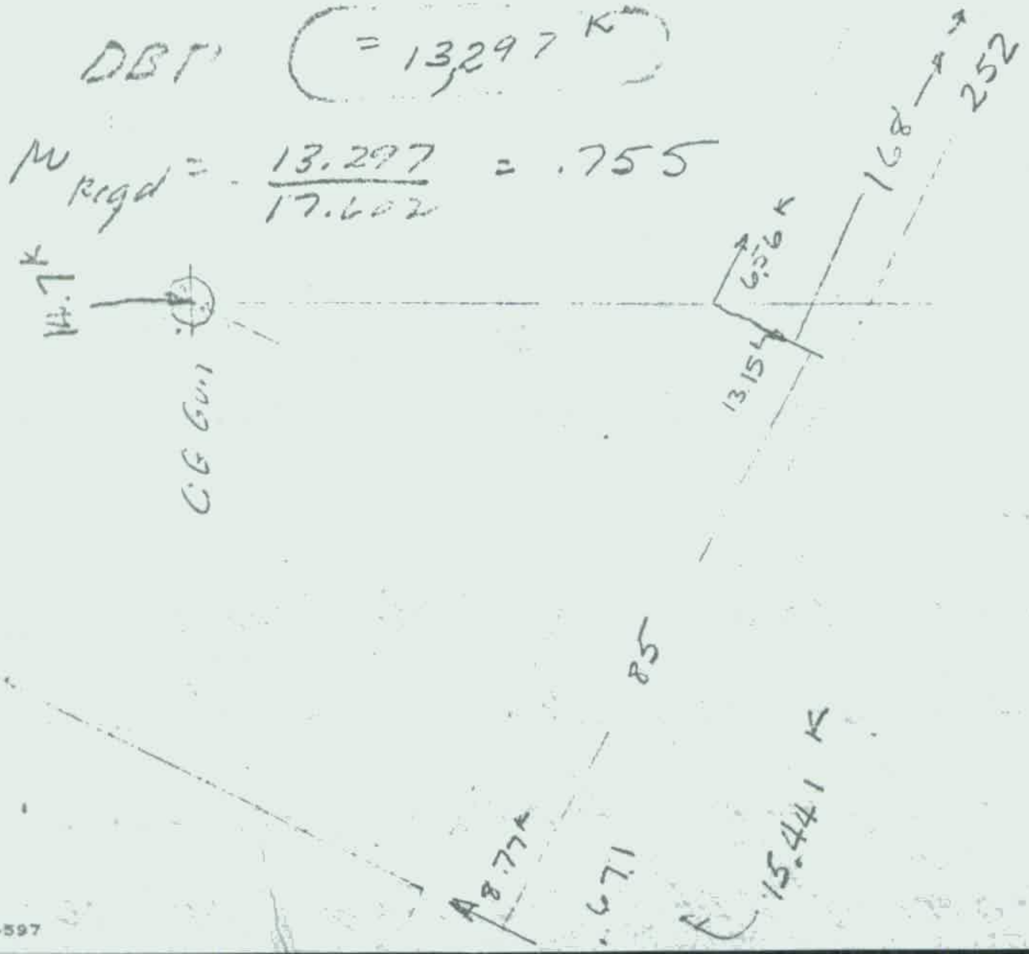
Actual μ must be greater
to surmount rolling resistance

resistance @ $\frac{17^{\#}}{1000}$ = 17 (28.7) = .487#

Total resistance = 12.81 + .487 =

DBP (= 13,297 K)

$\mu_{Reqd} = \frac{13.297}{17.602} = .755$



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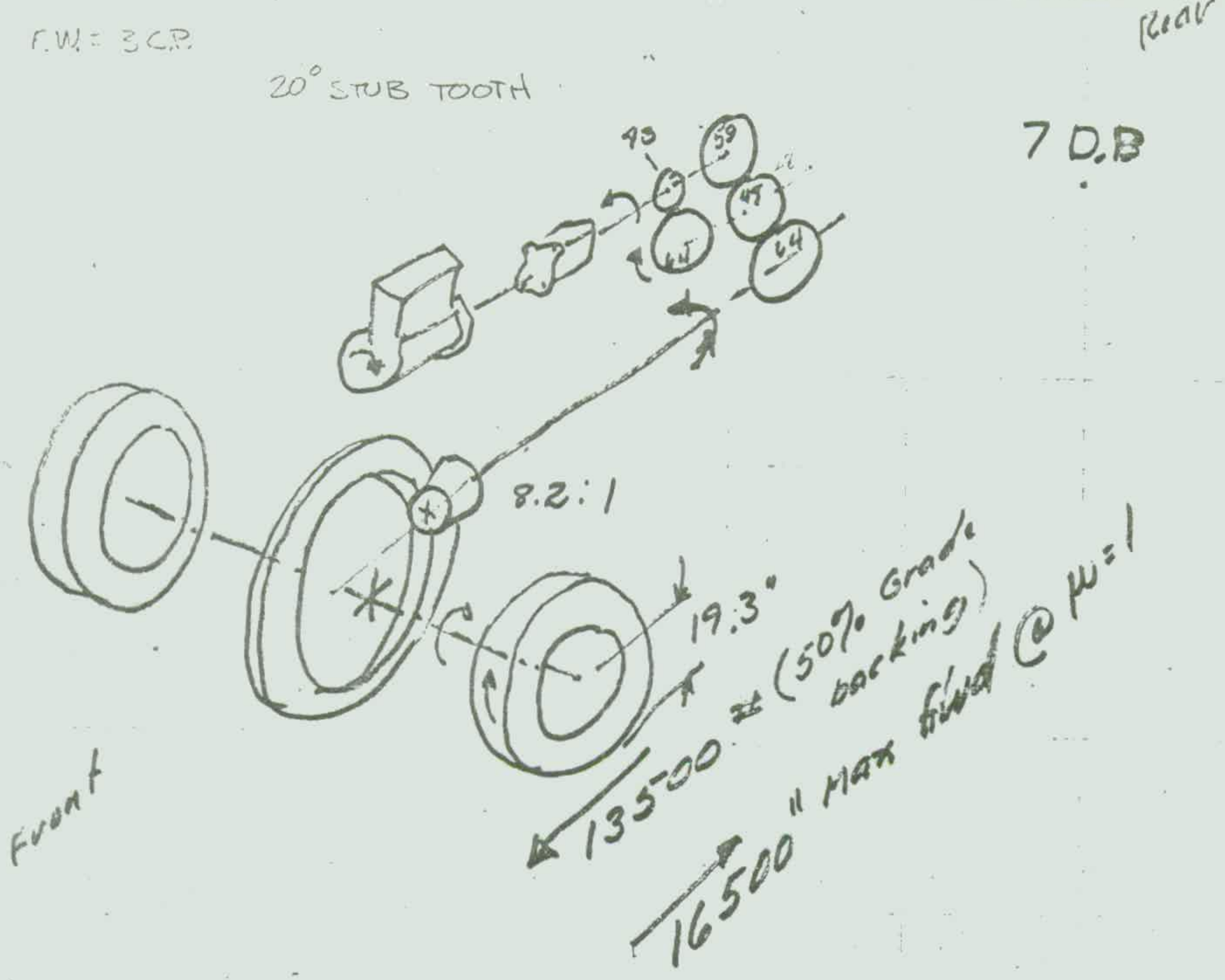
F.W. = 3CP

20° STUB TOOTH



Rotatiins are for backing up 50% grade. Force direction is for tire (Not grand reaction)

Altho 13500# is the force required for 50% grade, the normal design point for power trains assumes a coefficient of traction of μ = 1.00

and the maximum normal axle loading. The axle load is 16500 lbs. The gearing strength will be designed for this traction force although the gear ratios and engine torque will not attain this tractive effort

Axle design tractive force = 16500 #

" " torque = 19.3 (16,500)

= 318450

" Input torque = $\frac{318450}{8.2}$ = 38835.4

Transfer gear box output tq = 38835.4 lb

" Idler gear torque = $\frac{48}{64}$ (38835.4)

= 29126.5 lb in

" Input shaft tq (Transfer Low gear) = $\frac{43}{64}$ (29126.5)

= 19569.4 lb in

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DATE ______ REPORT NO. ______

Transfer input tq (High Gear) $= \left(\frac{59}{64}\right) 38835.4$

$= 35801.4$ lb in

Transmission gear ratios

Reverse ~~7.48:1~~ 6.30:1

1st ~~6.30:1~~ 7.48:1

Reqd engine torque in ~~reverse~~ 1st gear, Low transfer ra

$Tq_{eng} \quad \frac{19569.4}{7.48} = 2616.23$ lb in

$= 218.02$ lb-ft

Reqd engine torque in Reverse, Low transfer rat

$\frac{19569.4}{6.30} = 3106.25$ lb in

$= 258.85$ lb-ft

Gross rated engine torque = 259 ft lbs

GMC 4-53N (N 40 high economy)

PCF-RN-597

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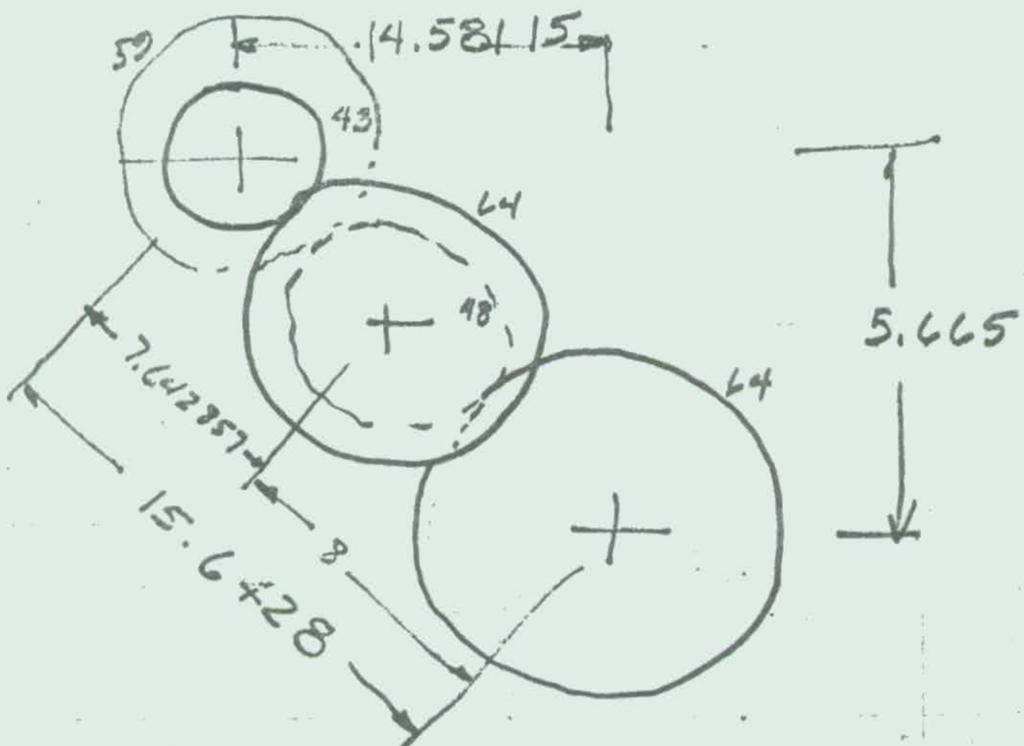
PAGE 5 OF

REPORT NO.



7 DP 20° PA STUB Fillet Root

No Teeth	Pitch Diam	Pitch Radius
43	6.142857	3.0 7142857
48	6.8571429	3.4285714
64	9.142857	4.5714286
59	8.428571	4,21428571

Tooth load @ gross eng tq, 1st gear (7.48:1)

43t $W_t = \frac{7.48(3106)}{3.07142} \cancel{19569.4} = 7564.2 \;\cancel{6371.45}$ 16 in

48T $W_t = \frac{29126.5}{3.42857} = 8495.23$ 16 in ✗

58T $W_t = \frac{3106 \quad 7.48}{4.214286} = \frac{23232.88}{4.214286} = 5512.89$

$$S_b = \frac{P\,W_t}{F\,Y} \qquad face = 1\tfrac{1}{8}$$

$$S_b = \frac{8495\;(7)}{1.125 \quad \cancel{.405}\;.471} = 112{,}300 \text{ psi} \longrightarrow$$

0 -1

@ Face = 1.5"

S_p = 84200 psi OK ⟶ 48t

$$S_p = \frac{7564.2 \quad 7}{1.5 \quad .462} = 76200 \text{ psi} \longrightarrow 43t$$

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DATE ______ REPORT NO. ______

TORQUE = 23,000 IN-lb

TOOTH LOAD ON 43 T GEAR:

$23{,}000 / 3.071 = 7{,}490 \text{ lbs} = W_t$

$S_b = \dfrac{P W_t}{F Y}$

$Y = .471$

$F = 1.75$

$P = 7$

$W_t = 7{,}490$

$S_b = \dfrac{(7)(7{,}490)}{(1.75)(.462)} = 65{,}000 \text{ PSI}$ 43T

TOOTH LOAD ON 48T GEAR:

$T = 23{,}000 \left(\dfrac{64}{43}\right) = 34{,}200 \text{ IN-lb}$

$W_t = 34{,}200 / 3.428 = 10{,}000 \text{ lb}$

$S_b = \dfrac{(7)(10{,}000)}{(1.75)(4.71)} = 85{,}000 \text{ PSI}$ 48T

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PAGE OF
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2-SPEED TRANSFER CASE

DESIGN PARAMETERS

LOW GEAR RATIO 1.984 : 1.0

HIGH GEAR RATIO 1.085 : 1.0

INPUT TORQUE: 23,000 IN-lb @ 240 RPM

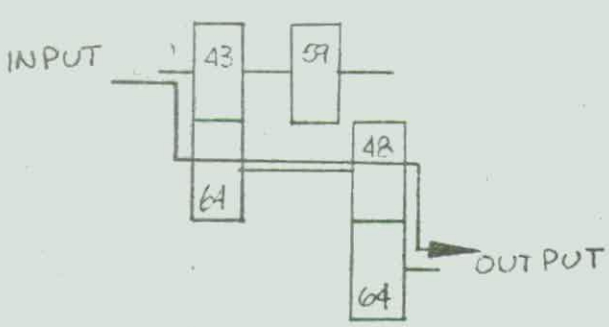
DIAMETRAL PITCH – 7

PRESSURE ANGLE – 20°

TOOTH FORM – STUB TOOTH, FILLET ROOT

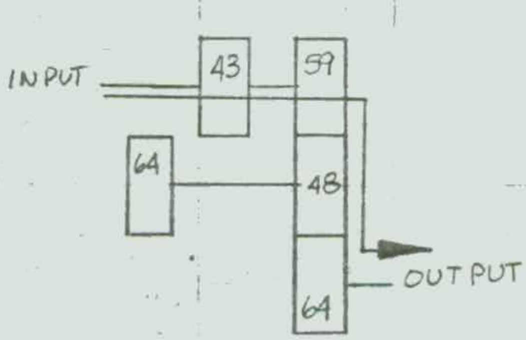
GEAR TRAIN SCHEMATIC

LOW



$$\frac{64}{48}\,\frac{64}{43} = 1.984496$$

HIGH



$$\frac{64}{59} = 1.084745$$

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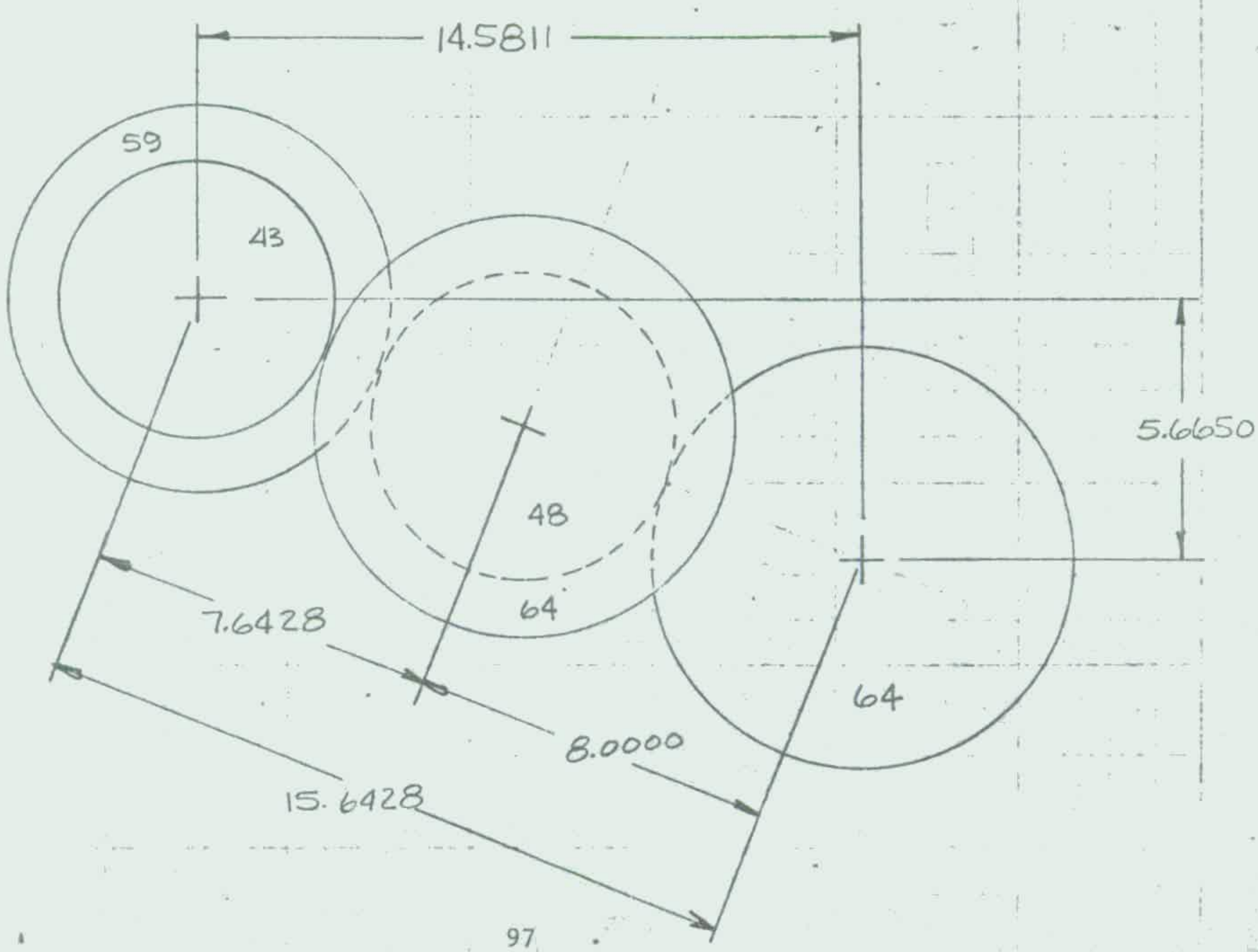
ORDER NO.

PAGE 2 OF

REPORT NO.

GEAR DATA

NO. TEETH	PITCH DIA
43	6.142857
48	6.857142
64	9.142857
59	8.428571



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FIND HERTZ STRESS FOR 48 TOOTH GEAR.

FROM "PRACTICAL GEAR DESIGN" - DUDLEY P.50

$$S_c = 5{,}715 \sqrt{\frac{W_t}{Fd}\left(\frac{m_G+1}{m_G}\right)}$$

W_t = TANGENTIAL FORCE = 10,000 lbs

F = FACE WIDTH = 1.50

d = PITCH DIAMETER = 6.86

m_G = GEAR TEETH/PINION TEETH = 64/48 = 1.33

$$S_c = 5{,}715 \sqrt{\frac{(10{,}000)(1.75)}{(1.5)(6.86)}} = 235{,}682 \text{ lb/in}^2$$

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LIFE & LOAD CALCULATION

FAFNIR 9117K @ 7500 lbs*

& 240 RPM**

RADIAL LOAD (RE) = 7500

FROM FAFNIR CATALOG 68: (P.13)

$$C_N = n_f \times C_B = (.51)(8530) = 4350 \text{ lb}$$

$$L_{10} = 1500\left(\frac{C_N}{RE}\right)^3 = 1500\left(\frac{4350}{7500}\right)^3$$

L_{10} = 292 HRS

* 23,000 IN-lb (INPUT) / 3.07

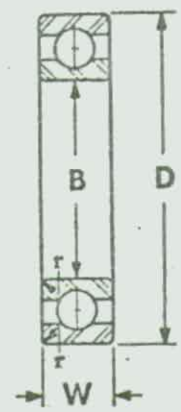
** 1800/7.48 = 240 RPM

M-R-C Brg. No.	BORE—B MM	BORE—B Inch	BORE—B Tol. (Ave.)¶ +.0000	OUTSIDE DIA.—D MM	OUTSIDE DIA.—D Inch	OUTSIDE DIA.—D Tol. (Ave.)¶ +.0000	WIDTH W Individual Rings MM	WIDTH W Inch	WIDTH W Tol. (Ave.)¶ +.000	RAD. r • Inch	BALLS No.	BALLS Size
0-S	10	.3937	-.0003	22	.8661	-.0004	6	.2362	-.005	.012	9	1/8
1-S	12	.4724	-.0003	24	.9449	-.0004	6	.2362	-.005	.012	9	9/64
1902-S	15	.5906	-.0003	28	1.1024	-.0004	7	.2756	-.005	.012	10	5/32
‡1903-S	17	.6693	-.0003	30	1.1811	-.0004	7	.2756	-.005	.012	11	5/32
‡1904-S	20	.7874	-.0004	37	1.4567	-.0005	9	.3543	-.005	.012	9	7/32
‡1905-S	25	.9843	-.0004	42	1.6535	-.0005	9	.3543	-.005	.012	11	7/32
‡1906-S	30	1.1811	-.0004	47	1.8504	-.0005	9	.3543	-.005	.012	13	7/32
1907-S	35	1.3780	-.0005	55	2.1654	-.0005	10	.3937	-.005	.025	13	1/4
1908-S	40	1.5748	-.0005	62	2.4409	-.0005	12	.4724	-.005	.025	13	9/32
‡1909-S	45	1.7717	-.0005	68	2.6772	-.0005	12	.4724	-.005	.025	16	1/4
†‡1910-S	50	1.9685	-.0005	72	2.8346	-.0005	12	.4724	-.005	.025	16	9/32
1911-S	55	2.1654	-.0006	80	3.1496	-.0005	13	.5118	-.005	.04	16	5/16
1912-S	60	2.3622	-.0006	85	3.3465	-.0006	13	.5118	-.005	.04	17	5/16
1913-S	65	2.5591	-.0006	90	3.5433	-.0006	13	.5118	-.005	.04	18	5/16
1914-S	70	2.7559	-.0006	100	3.9370	-.0006	16	.6299	-.005	.04	17	11/32
§1915-S	75	2.9528	-.0006	105	4.1339	-.0006	16	.6299	-.005	.04	17	3/8
1916-S	80	3.1496	-.0006	110	4.3307	-.0006	16	.6299	-.005	.04	[illegible]	3/8
1917-S	85	3.3465	-.0008	120	4.7244	-.0006	18	.7087	-.005	.04	16	15/32
1918-S	90	3.5433	-.0008	125	4.9213	-.0008	18	.7087	-.005	.04	17	15/32
§1919-S	95	3.7402	-.0008	130	5.1181	-.0008	18	.7087	-.005	.04	17	15/32
1920-S	100	3.9370	-.0008	140	5.5118	-.0008	20	.7874	-.005	.04	17	1/2
1921-S	105	4.1339	-.0008	145	5.7087	-.0008	20	.7874	-.005	.04	18	1/2
1922-S	110	4.3307	-.0008	150	5.9055	-.0008	20	.7874	-.005	.04	19	1/2
1924-S	120	4.7244	-.0008	165	6.4961	-.0010	22	.8661	-.005	.04	18	9/16
§1926-S	130	5.1181	-.0010	180	7.0866	-.0010	24	.9449	-.005	.06	18	5/8
§1928-S	140	5.5118	-.0010	190	7.4803	-.0012	24	.9449	-.005	.06	19	5/8
§1930-S	150	5.9055	-.0010	210	8.2677	-.0012	28	1.1024	-.005	.08	17	3/4
§1932-S	160	6.2992	-.0010	220	8.6614	-.0012	28	1.1024	-.005	.08	18	3/4
§1934-S	170	6.6929	-.0010	230	9.0551	-.0012	28	1.1024	-.005	.08	19	3/4
§1936-S	180	7.0866	-.0010	250	9.8425	-.0012	33	1.2992	-.005	.08	17	7/8
§1938-S	190	7.4803	-.0012	260	10.2362	-.0014	33	1.2992	-.010	.08	18	7/8
§1940-S	200	7.8740	-.0012	280	11.0236	-.0014	38	1.4961	-.010	.08	17	1

M-R-C SINGLE-ROW DEEP-GROOVE BEARINGS TYPE S

MRC 1900-S

Extremely Light Series



Shaft Fits—see pages 150-155.

Housing Fits—see pages 156-161.

Shaft Shoulders, Housing Shoulders—see page 146.

• Radius "r" indicates maximum radius on shaft or in housing bearing corner will clear.

† Also available with one shield, typ and two shields, type SFF.

‡ Also available with one seal, typ and two seals, type- SZZ.

§ This size not presently made bu be available as production re ments justify tooling.

¶ See page 168.

Note: Tolerances shown on this are ABEC-1 standard.

RATED RADIAL LOAD CAPACITY in POUNDS (Based on 500 hours minimum life; for calculation of life expectancies see page 173.) (For ratings at speeds not listed, see page 172; for limiting speeds, see page 187.)

M-R-C Bearing Number	33⅓*	50	100	200	300	400	500	600	700
1900-S	465	405	325	255	225	205	190	180	170
1901-S	580	505	400	320	280	250	235	215	210
1902-S	750	655	520	410	360	325	305	285	270
1903-S	795	695	550	435	380	345	320	305	290
1904-S	1280	1120	885	705	615	560	520	490	465
1905-S	1460	1270	1010	800	700	635	590	555	530
1906-S	1610	1410	1120	885	775	705	655	615	585
1907-S	2040	1780	1420	1120	980	890	830	780	740
1908-S	2520	2200	1750	1390	1210	1100	1020	965	915
1909-S	2260	1980	1570	1240	1090	985	915	865	820
1910-S	2810	2460	1950	1550	1350	1230	1140	1070	1020
1911-S	3410	2980	2360	1870	1640	1490	1380	1300	1230
1912-S	3500	3060	2430	1930	1680	1530	1420	1340	1270
1913-S	3590	3140	2490	1980	1730	1570	1460	1370	1300
1914-S	4100	3580	2840	2260	1970	1790	1660	1570	1490
1915-S	4820	4210	3340	2650	2320	2100	1950	1840	1750
1916-S	4950	4330	3440	2730	2380	2150	2010	1890	1800
1917-S	7050	6160	4890	3880	3390	3080	2860	2690	2560
1918-S	7280	6360	5050	4010	3500	3180	2950	2780	2640
1919-S	7240	6320	5020	3980	3480	3160	2930	2760	2620
1920-S	8100	7070	5620	4460	3890	3540	3280	3090	2940
1921-S	8350	7300	5790	4600	4020	3650	3390	3190	3030
1922-S	8590	7500	5950	4730	4130	3750	3480	3280	3110
1924-S	10280	8980	7130	5660	4940	4490	4170	3920	3730
1926-S	12480	10900	8650	6870	6000	5450	5060	4760	4520
1928-S	12780	11160	8860	7030	6140	5580	5180	4880	4630
1930-S	16800	14680	11650	9250	8080	7340	6810	6410	6090
1932-S	17250	15070	11960	9490	8290	7540	7000	6580	6250
1934-S	17720	15480	12290	9750	8520	7740	7190	6760	6420
1936-S	22080	19290	15310	12150	10610	9640	8950	8420	8000
1938-S	22730	19860	15760	12510	10930	9930	9220	8670	8240
1940-S	28200	24640	19550	15520	13560	12320	11430	10760	10220

M-R-C Bearing Number	800	900	1000	1200	1500	1800	2000	2500	3000	3600
1900-S	160	155	150	140	130	125	120	110	105	10
1901-S	200	195	185	175	160	155	150	135	130	12
1902-S	260	250	240	225	210	200	190	175	165	15
1903-S	275	265	255	240	225	210	205	190	175	16
1904-S	445	425	410	390	360	340	325	305	285	27
1905-S	505	485	470	440	410	385	370	345	325	3
1906-S	560	535	520	490	455	425	410	380	360	3
1907-S	710	680	655	620	575	540	520	485	455	4
1908-S	875	840	810	765	710	670	645	600	565	5
1909-S	785	755	730	685	635	600	575	535	505	4
1910-S	975	940	905	850	790	745	720	665	630	5
1911-S	1180	1140	1100	1030	955	900	870	810	760	7
1912-S	1210	1170	1130	1060	985	925	895	830	780	7
1913-S	1240	1200	1160	1090	1010	950	915	850	800	7
1914-S	1420	1370	1320	1240	1150	1090	1050	970	915	8
1915-S	1670	1610	1550	1460	1350	1280	1230	1140	1080	10
1916-S	1720	1650	1590	1500	1390	1310	1270	1180	1110	10
1917-S	2440	2350	2270	2140	1980	1870	1800	1670	1570	14
1918-S	2530	2430	2340	2210	2050	1930	1860	1730	1630	1
1919-S	2510	2410	2330	2190	2030	1910	1850	1720	1610	1
1920-S	2810	2700	2610	2450	2280	2140	2070	1920	1810	1
1921-S	2900	2780	2690	2530	2350	2210	2130	1980	1860	1
1922-S	2980	2860	2760	2600	2410	2270	2190	2040	1920	1
1924-S	3560	3430	3310	3110	2890	2720	2630	2440	2290	2
1926-S	4330	4160	4020	3780	3510	3300	3190	2960	2790	2
1928-S	4430	4260	4110	3870	3590	3380	3260	3030	2850	2
1930-S	5830	5600	5410	5090	4720	[illegible]	4290	3980	3750	[illegible]
1932-S	5980	5750	5550	5220	4850	4560	4410	4090	[illegible]	[illegible]
1934-S	6140	5910	5700	5370	4980	4690	4530	4200	[illegible]	[illegible]
1936-S	7650	7360	7110	6690	6210	5840	5640	5240	4930	[illegible]
1938-S	7880	7580	7320	6880	6390	6010	5810	5390	5070	[illegible]
1940-S	9780	9400	9080	8540	7930	7460	7200	6690	[illegible]	[illegible]

Note: Load ratings based on A

* Specific dynamic capacity.

THRUST LOAD is present, see page 9.

LIFE AND LOAD CALCULATION FOR

TIMKIN ROLLER BEARING 39520 CUP
39590 CONE

$RPM = 240 \frac{43}{64} = 161$ RPM

RADIAL LOAD (RE):

$23{,}000 \left(\frac{64}{43}\right) \frac{1}{3.43} = 9{,}950$

RRR = (RE)(LF) x (AF) / SF (P. B-19)

RE = 9,950 lb

LF = .719 1000 HRS (P. B-13)

AF = 1.0

SF = 1.41 (P. B-12)

RRR = (9,950)(.719)/1.41 = 5060 lbs

@ 500 RPM

BRR = 6100 lbs @ 500 RPM

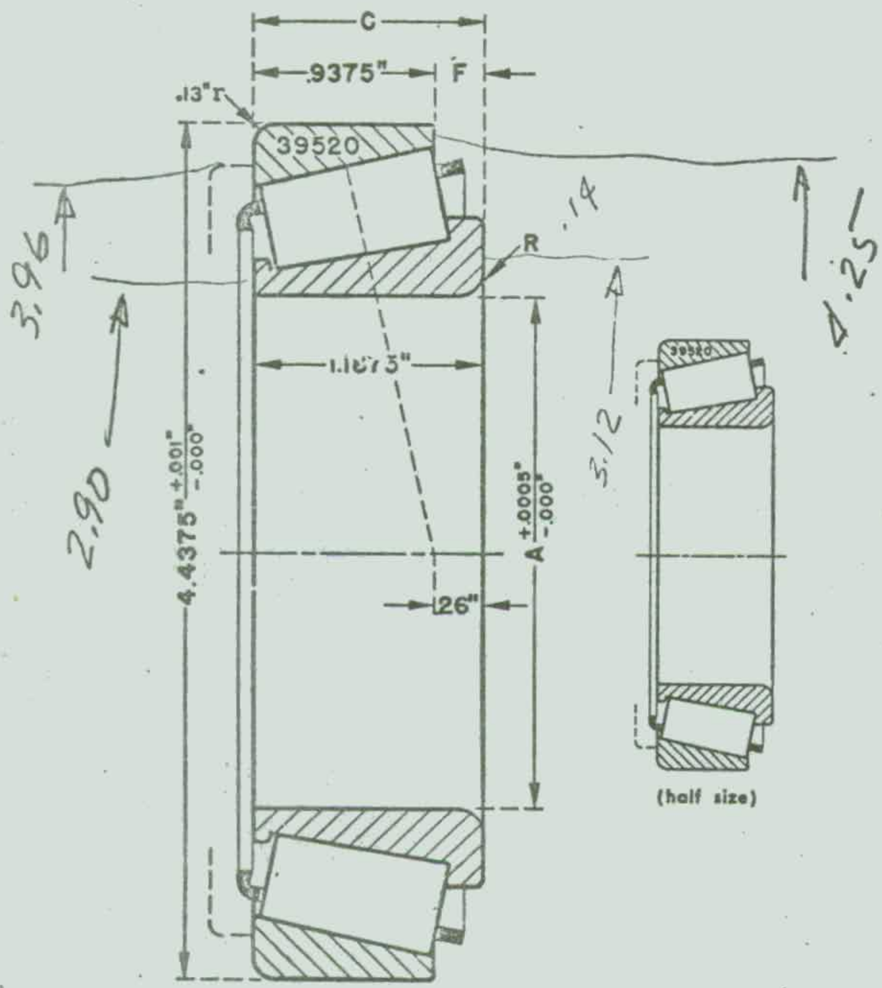
maximum bore

available in types
TS
TSF
TDI

cone			cup no. 39520		bearing width	cup no. 39522		bearing width	cup no. 39528		bearing width
bore A	radius R	number	outside diameter	standout F	C	outside diameter	standout F	C	outside diameter	standout F	C
2.0000	.03	39573	4.4375	.2500	1.1875	4.4375	.2500	1.4375	4.7238	.2284	1.2894
2.0000	.14	39575									
2.1250	.14	39578									
2.2500	.14	39580									
2.2500	.31	39581									
2.5000	.14	39585				length = 1.1875" radius = .13"			length = 1.0610" radius = .03"		
*2.5585	.09	39586									
2.6250	.14	39590									

*cone length = 1.2175"

any cone in this series may be used with any cup in this series.



(half size)

basic rating @ 500 rpm

radial (BRR)	6100 lbs.
thrust (BTR)	3550 lbs.
K	1.72

use modifying factors to compare Timken bearing capacity-ratings with other makes of bearings.

The Timken Roller Bearing Company

9. Compensation of misalignment


Self-aligning ball bearings, barrel roller bearings, radial spherical roller bearings, and spherical roller thrust bearings allow, on assembly, for the correction of initial misalignment. The outer ring raceway of these bearings is of a spherical form which allows the inner ring/roller set assembly to undergo swivelling motions. The permissible angular misalignment depends on bearing design and size.

It is also possible for the deep groove ball bearings to accept some misalignment; however, this is limited and dependent on the amount of radial clearance; the greater the clearance the greater the self-aligning ability. Cylindrical roller bearings and tapered roller bearings may achieve a limited amount of self-alignment by the provision of crowned or cambered raceways and rollers.

Table 6 presents information on the amounts of permissible angular misalignment.

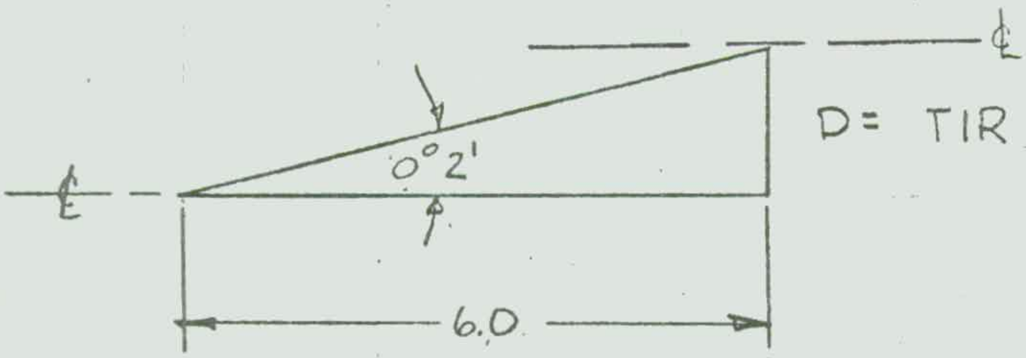

6. Permissible angular misalignment

Bearing type		Misalignment
self-aligning ball bearings		4°
barrel roller bearings		4°
spherical roller bearings		0.5°
spherical roller thrust bearings		3°
deep groove ball bearings, standard clearance	mating parts machined to k 5/J 6	8′
deep groove ball bearings, C3 clearance		12′
deep groove ball bearings, C4 clearance		16′
cylindrical roller bearings types N and NU, series 10, 2, 3, 4, RLS, RL L, RMS and RM L		4′
cylindrical roller bearings, any other types and series		2′
tapered roller bearings		2′

The prime causes of initial misalignment are the differences in height between the mounting seats of the housing support structures, for instance between the base plates of plummer blocks, or misalignment of housing bores if they are not machined in one setting.

Self-aligning bearings are also chosen in cases where dynamic misalignment through major shaft deflections or housing deformation is to be expected. The spherical basis of design automatically allows the bearing to correct for the misaligned condition. If rigid bearings were provided in such applications they would be subject to a tilting pressure with consequent additional stressing.

Under load a bearing ring should only be swivelled when the bearing rotates. Rotation is essential to ensure adequate lubrication between rolling elements and raceways. Adequacy of lubrication is in its turn required to neutralize the effects of sliding occurring between rollers and raceways during swivelling. Thrust ball bearings are sensitive to out-of-squareness between abutment surface and bearing axis. Machining errors of this sort can be corrected by the provision of spherical housing washers and seating washers. Thrust ball bearings with spherical housing washers and seating washers are of the single or double-acting type.



$$\tan 0°2' = \frac{TIR}{6}$$

$$TIR = (\tan 2')6 = .00058(6) = .00348$$

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

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LIFE AND LOAD CALCULATION FOR

SKF 6213

$2P = 34{,}200 / 3.43 = 9{,}950$ lbs

$P = 4970$ lbs

$RPM = 161 \frac{48}{64} = 121$

c/p FOR 1000 HRS = 1.95

C = BASIC DYNAMIC LOAD RATING FROM TABLE

$C = (1.95)(4970) = 9{,}700$ lbs

C FOR 6213 = 9,900 lbs

PCF-RN-597

FIND STRESS IN OUTPUT SHAFT

$$\tau = \frac{Tr}{J} = \frac{32(T)(r)}{(3.14)(d_o^4 - d_i^4)}$$

$$\tau = \frac{(32)(45{,}632)(1.0)}{(3.14)(16)} = 29{,}064 \text{ lb/in}^2$$

$$T = 23{,}000(1.984) = 45{,}632 \text{ in-lb}$$

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ORDER NO.

PAGE OF

REPORT NO.

SPLINE $8/16 = P/P_s$

$P =$ DIAMETRAL PITCH $= 8$

$P_s =$ STUB PITCH $= 16$

$1.000/P_s =$ ADDENDUM $= .062$

SIDE FIT (loose) CLASS 1

(MODIFY DIMS DEPENDING ON FINISH (phosphate coating, etc.))

		INTERNAL MAJ DIA	INTERNAL MINOR DIA	EXTERNAL MAJ DIA	EXTERNAL MINOR DIA
PITCH DIA	2.50				
NO. TEETH	20	2.6250	2.3750	2.5960	2.3460
PITCH DIA	3.50				
NO. TEETH	28	3.6250	3.3750	3.5960	3.3460

TABLE 10—FLAT ROOT SIDE FIT—8/16 PITCH

Internal and External			Internal Drawing Data Fig. 5					External Drawing Data Fig. 6						
						Space Width[a]		Tooth Thickness[a]						
								Class 1 Fit		Class 2 Fit				
N No. of Teeth	D Pitch Dia	D_b Base Dia	D_{ri} Major Dia	D_{Fi} Form Dia	D_i Minor Dia[d]	s Max Actual	s_v Min Effect	t_v Max Effect	t Min Actual	t_v Max Effect	t Min Actual	D_o Major Dia	D_{Fe} Form Dia	D_{re} Minor Dia
1	2	3	4.1	5.1	6.1	8	9	10	11	12	13	14.1	17.1	18.1
Tolerance in Ten Thousandths →			+160 −0	—	+50 −0	Note[b]	Note[c]	Note[c]	Note[b]	Note[c]	Note[b]	+0 −50	Note[d]	+0 −180
6	0.7500	0.6495	0.8750	0.8500	0.6635	0.1991	0.1963	0.1949	0.1920	0.1963	0.1935	0.8460	0.6595	0.5960
7	0.8750	0.7578	1.0000	0.9750	0.7761	0.1991	0.1963	0.1949	0.1920	0.1963	0.1935	0.9710	[illegible]	0.7210
8	1.0000	0.8660	1.1250	1.1000	0.8953	0.1992	0.1963	0.1949	0.1919	0.1963	0.1934	1.0960	0.8913	0.8460
9	1.1250	0.9743	1.2500	1.2250	1.0159	0.1992	0.1963	0.1949	0.1919	0.1963	0.1934	1.2210	1.0119	0.9710
10	1.2500	1.0825	1.3750	1.3500	1.1374	0.1993	0.1963	0.1948	0.1918	0.1963	0.1934	1.3460	1.1334	1.0960
11	1.3750	1.1908	1.5000	1.4750	1.2596	0.1993	0.1963	0.1948	0.1918	0.1963	0.1933	1.4710	1.2556	1.2210
12	1.5000	1.2990	1.6250	1.6000	1.3823	0.1993	0.1963	0.1948	0.1918	0.1963	0.1933	1.5960	1.3783	1.3460
13	1.6250	1.4073	1.7500	1.7250	1.5054	0.1994	0.1963	0.1948	0.1918	0.1963	0.1932	1.7210	1.5014	1.4710
14	1.7500	1.5155	1.8750	1.8500	1.6288	0.1994	0.1963	0.1948	0.1917	0.1963	0.1932	1.8460	[illegible]	1.5960
15	1.8750	1.6238	2.0000	1.9750	1.7524	0.1994	0.1963	0.1948	0.1916	0.1963	0.1932	1.9710	1.7484	1.7210
16	2.0000	1.7321	2.1250	2.1000	1.8762	0.1995	0.1963	0.1948	0.1916	0.1963	0.1931	2.0960	1.8722	1.8460
17	2.1250	1.8403	2.2500	2.2253	2.0004	0.1995	0.1963	0.1948	0.1915	0.1963	0.1931	2.2210	1.9962	1.9710
18	2.2500	1.9486	2.3750	2.3505	2.1250	0.1995	0.1963	0.1948	0.1915	0.1963	0.1931	2.3460	2.1205	2.0960
19	2.3750	2.0568	2.5000	2.4758	2.2500	0.1996	0.1963	0.1948	0.1914	0.1963	0.1930	2.4710	2.2452	2.2210
20	2.5000	2.1651	2.6250	2.6010	2.3750	0.1996	0.1963	0.1947	0.1194	0.1963	0.1930	2.5960	2.3700	2.3460
21	2.6250	2.2733	2.7500	2.7263	2.5000	0.1996	0.1963	0.1947	0.1913	0.1963	0.1930	2.7210	2.4948	2.4710
22	2.7500	2.3816	2.8750	2.8515	2.6250	0.1997	0.1963	0.1947	0.1913	0.1963	0.1929	2.8460	2.6195	2.5960
23	2.8750	2.4898	3.0000	2.9768	2.7500	0.1997	0.1963	0.1947	0.1913	0.1963	0.1929	2.9710	2.7442	2.7210
24	3.0000	2.5981	3.1250	3.1020	2.8750	0.1997	0.1963	0.1947	0.1912	0.1963	0.1929	3.0960	2.8690	2.8450
25	3.1250	2.7063	3.2500	3.2273	3.0000	0.1998	0.1963	0.1947	0.1912	0.1963	0.1928	3.2210	2.9938	2.9710
26	3.2500	2.8146	3.3750	3.3525	3.1250	0.1998	0.1963	0.1947	0.1911	0.1963	0.1928	3.3460	3.1185	3.0960
27	3.3750	2.9228	3.5000	3.4778	3.2500	0.1999	0.1963	0.1947	0.1911	0.1963	0.1928	3.4710	3.2432	3.2210
28	3.5000	3.0311	3.6250	3.6030	3.3750	0.1999	0.1963	0.1947	0.1910	0.1963	0.1927	3.5960	3.3680	3.3460
29	3.6250	3.1393	3.7500	3.7282	3.5000	0.1999	0.1963	0.1947	0.1910	0.1963	0.1927	3.7210	[illegible]	3.4710
30	3.7500	3.2476	3.8750	3.8535	3.6250	0.2000	0.1963	0.1946	0.1909	0.1963	0.1926	3.8460	3.6175	3.5960
31	3.8750	3.3558	4.0000	3.9788	3.7500	0.2000	0.1963	0.1946	0.1909	0.1963	0.1926	3.9710	3.7422	3.7210
32	4.0000	3.4641	4.1250	4.1040	3.8750	0.2000	0.1963	0.1946	0.1909	0.1963	0.1926	4.0960	3.8670	3.8460
33	4.1250	3.5724	4.2500	4.2293	4.0000	0.2001	0.1963	0.1946	0.1908	0.1963	0.1925	4.2210	3.9918	3.9710
34	4.2500	3.6806	4.3750	4.3545	4.1250	0.2001	0.1963	0.1946	0.1908	0.1963	0.1925	4.3460	4.1165	4.0960
35	4.3750	3.7889	4.5000	4.4798	4.2500	0.2001	0.1963	0.1946	0.1907	0.1963	0.1925	4.4710	4.2412	4.2210
36	4.5000	3.8971	4.6250	4.6050	4.3750	0.2002	0.1963	0.1946	0.1907	0.1963	0.1924	4.5960	4.3660	4.3460
37	4.6250	4.0054	4.7500	4.7303	4.5000	0.2002	0.1963	0.1946	0.1906	0.1963	0.1924	4.7210	4.4908	4.4710
38	4.7500	4.1136	4.8750	4.8555	4.6250	0.2002	0.1963	0.1946	0.1906	0.1963	0.1924	4.8460	4.6155	4.5960
39	4.8750	4.2219	5.0000	4.9808	4.7500	0.2003	0.1963	0.1946	0.1905	0.1963	0.1923	4.9710	4.7402	4.7210
40	5.0000	4.3301	5.1250	5.1060	4.8750	0.2003	0.1963	0.1945	0.1905	0.1963	0.1923	5.0960	4.8650	4.8460
41	5.1250	4.4384	5.2500	5.2313	5.0000	0.2003	0.1963	0.1945	0.1905	0.1963	0.1923	5.2210	4.9898	4.9710
42	5.2500	4.5466	5.3750	5.3365	5.1250	0.2004	0.1963	0.1945	0.1904	0.1963	0.1922	5.3460	5.1145	5.0960
43	5.3750	4.6549	5.5000	5.4818	5.2500	0.2004	0.1963	0.1945	0.1904	0.1963	0.1922	5.4710	5.2392	5.2210
44	5.5000	4.7631	5.6250	5.6070	5.3750	0.2004	0.1963	0.1945	0.1903	0.1963	0.1922	5.5960	5.3640	5.3460
45	5.6250	4.8714	5.7500	5.7323	5.5000	0.2005	0.1963	0.1945	0.1903	0.1963	0.1921	5.7210	5.4888	5.4710
46	5.7500	4.9796	5.8750	5.8575	5.6250	0.2005	0.1963	0.1945	0.1902	0.1963	0.1921	5.8460	5.6135	5.5960
47	5.8750	5.0879	6.0000	5.9828	5.7500	0.2005	0.1963	0.1945	0.1902	0.1963	0.1921	5.9710	5.7382	5.7210
48	6.0000	5.1962	6.1250	6.1080	5.8750	0.2006	0.1963	0.1945	0.1901	0.1963	0.1920	6.0960	5.8630	5.8460
49	6.1250	5.3044	6.2500	6.2333	6.0000	0.2006	0.1963	0.1945	0.1901	0.1963	0.1920	6.2210	5.9878	5.9710
50	6.2500	5.4127	6.3750	6.3585	6.1250	0.2007	0.1963	0.1944	0.1900	0.1963	0.1919	6.3460	6.1125	6.0960
51	6.3750	5.5209	6.5000	6.4838	6.2500	0.2007	0.1963	0.1944	0.1900	0.1963	0.1919	6.4710	6.2372	6.2210
52	6.5000	5.6292	6.6250	6.6090	6.3750	0.2007	0.1963	0.1944	0.1900	0.1963	0.1919	6.5960	6.3620	6.3460
53	6.6250	5.7374	6.7500	6.7343	6.5000	0.2008	0.1963	0.1944	0.1899	0.1963	0.1918	6.7210	6.4868	6.4710
54	6.7500	5.8457	6.8750	6.8595	6.6250	0.2008	0.1963	0.1944	0.1899	0.1963	0.1918	6.8460	6.6115	6.5960
55	6.8750	5.9539	7.0000	6.9848	6.7500	0.2008	0.1963	0.1944	0.1898	0.1963	0.1918	6.9710	6.7362	6.7210
56	7.0000	6.0622	7.1250	7.1100	6.8750	0.2009	0.1963	0.1944	0.1898	0.1963	0.1917	6.0960	6.8610	6.8460
57	7.1250	6.1704	7.2500	7.2353	7.0000	0.2009	0.1963	0.1944	0.1897	0.1963	0.1917	7.2210	6.9858	6.9710
58	7.2500	6.2787	7.3750	7.3605	7.1250	0.2009	0.1963	0.1944	0.1897	0.1963	0.1917	7.3460	7.1105	7.0960
59	7.3750	6.3870	7.5000	7.4858	7.2500	0.2010	0.1963	0.1944	0.1896	0.1963	0.1916	7.4710	7.2352	7.2210
60	7.5000	6.4952	7.6250	7.6110	7.3750	0.2010	0.1963	0.1943	0.1896	0.1963	0.1916	7.5960	7.3600	7.3460

[a] Measurements with pins cannot be used to determine effective space width and tooth thickness. Measurements with pins for actual space width and tooth thickness are in Tables 62, 63, and 64.

[b] For (REF) minimum actual space width, and (REF) maximum actual tooth thickness, see Table 39.

[c] For (REF) maximum effective space width, and (REF) minimum effective tooth thickness, see Table 39.

[d] Figures in bold type are modified values, see Section 40.

1.312
2|2.625.

1.298
2|2.596

2.937
2|5.875

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY ______ ORDER NO. ATLAS TRNSTR

CHECKED BY ______ PAGE ______ OF ______

DATE ______ REPORT NO. ______

LEWIS STRESS FOR 43T PINION:

$$S_L = \frac{P\omega_t}{FY} = 65{,}000 \text{ Psi}$$

$$\text{ALMEN STRESS} = \frac{S_L}{(C.R.)(\cos\phi)}$$

$$\text{ALMEN STRESS} = \frac{65{,}000}{(1.437)(.939)} = 48{,}500 \text{ Psi}$$

PCF-DN-597

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

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HERTZ STRESS: 43T PINION

$$S_c = 5715\sqrt{\frac{W_t}{Fd}\,\frac{(m_G+1)}{m_G}}$$

$W_t = 7{,}500$

$F = 1.75$

$d = 6.143$

$m_G = 64/43 = 1.49$

$$S_c = 5715\sqrt{\frac{7500}{(1.75)(6.143)}\,\frac{2.49}{1.49}}$$

$S_c = 195{,}139$ PSI

PCF-RN-597

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DATE ________ REPORT NO. ________

$\rho = d \sin\phi/2 \qquad \sin\phi = \sin 20^\circ = .34202$

$\rho = (6.143)(.34202)/2 = 1.050 = R_1$

$\rho = (9.143)(.34202)/2 = 1.564 = R_2$

$$B = \sqrt{\frac{16F(K_1+K_2)(R_1)(R_2)}{L(R_1+R_2)}}$$

F = 7500 lbs

L = 1.75 IN

$$K_1 = K_2 = \frac{1-\nu^2}{\pi E} = \frac{1-.3^2}{(3.14)(29)(10^6)} = 1 \times 10^{-8}$$

$K_1 + K_2 = 2(10^{-8})$

$$B = \sqrt{\frac{(16)(7500)(2)(10^{-8})(1.05)(1.564)}{(1.75)(2.614)}}$$

$B = \sqrt{.000861} = .029$

$Z = .393\,B$

Z = .011 INCHES

PACIFIC CAR AND FOUNDRY COMPANY

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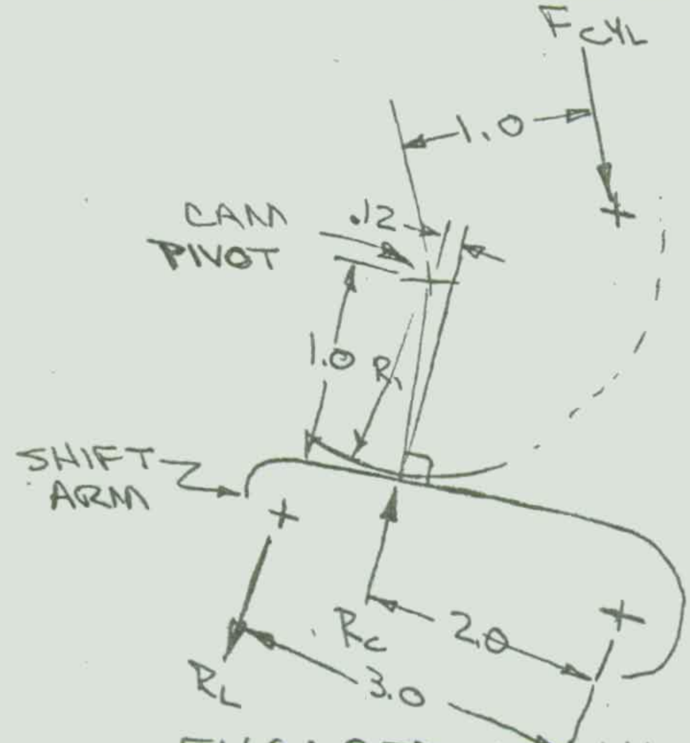
ORDER NO.

PAGE 1 OF

REPORT NO.

TRANSFER CASE HI-RANGE LOCK-OUT



ENGAGED IN HI-RANGE

FOR 1.06 BORE X .313 ROD DIA

ROD END FORCE MAX

$F_{ROD} = \pi/4\,(D_B^2 - D_R^2)\,P$

@ 60 PSI

(FOR OPERATING MARGIN)

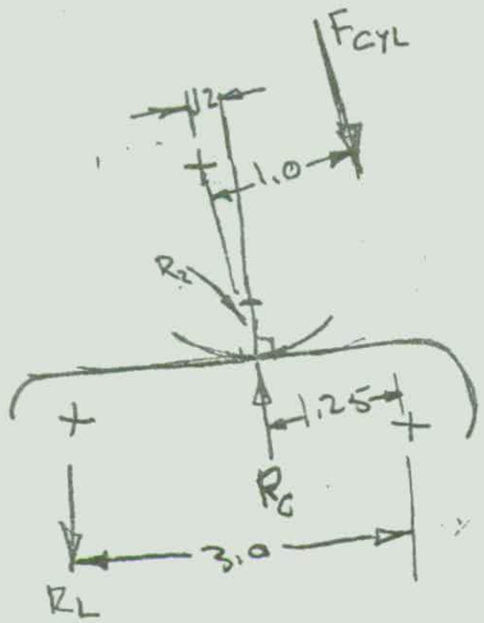
$F_{ROD} = \pi/4\,(1.063^2 - .313^2)(60)$

$= 48.6\#$

IF THIS IS STORED IN THE SPRING

$R_L = \dfrac{48.6(1.0)}{.12} \times \dfrac{2.0}{3.0}$

$= 270\#$



NEUTRAL

@ 60 PSI

$R_L = \dfrac{48.6(1.0)}{.12} \times \dfrac{1.25}{3}$

$= 169\#$

SHOULD PROVIDE ADEQUATE RESISTANCE TO SHIFTING BACK INTO HIGH RANGE

(PRESS NORMALLY 100 PSI)

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

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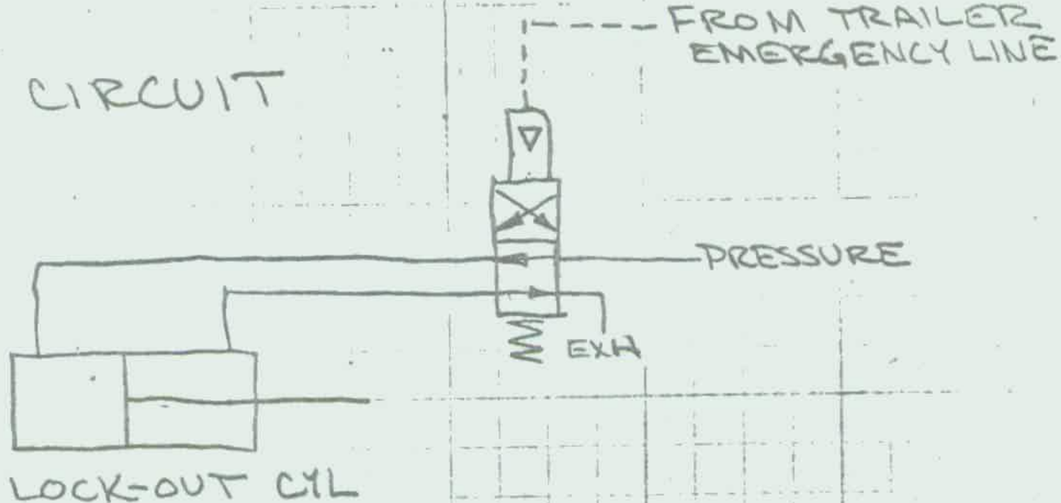
DATE 1/15/74

ORDER NO.

PAGE 2 OF

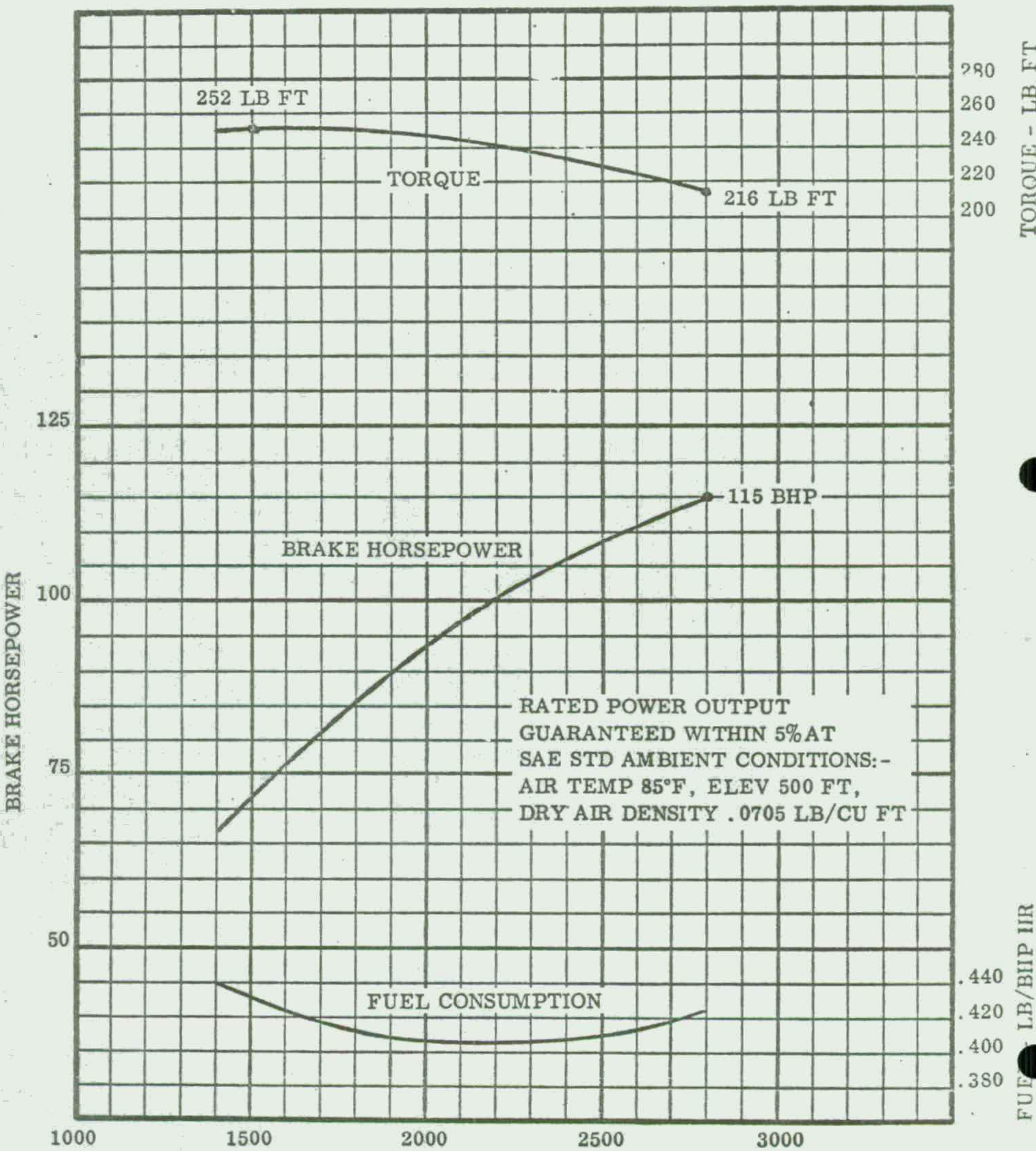
REPORT NO.

AIR CIRCUIT



DETROIT DIESEL ENGINE DIVISION
GENERAL MOTORS CORPORATION

BASIC ENGINE
MODEL 4-53N DIESEL
(4 VALVE HEAD)
N40 INJECTORS



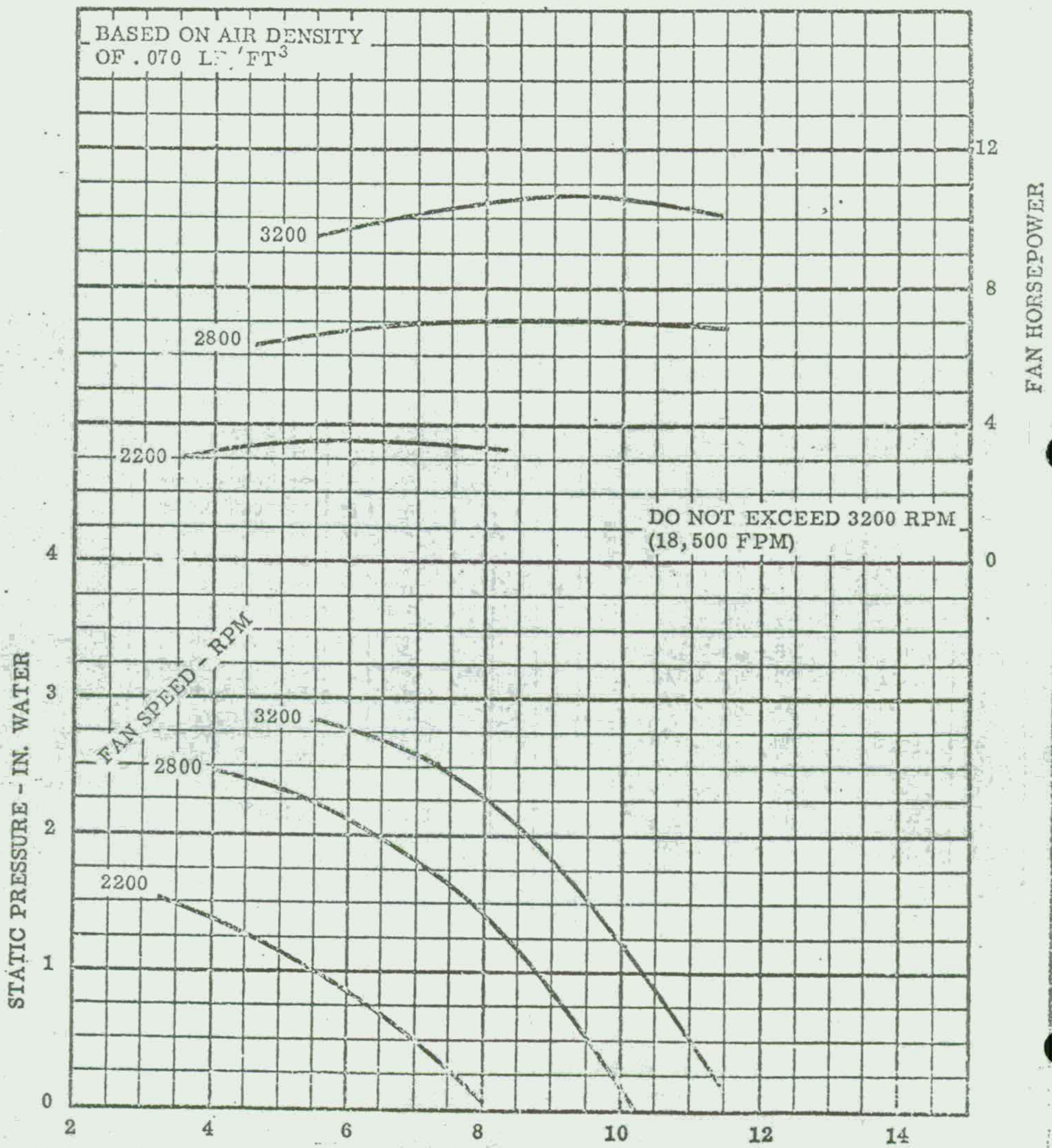
E4-5041-52-4
3/17/64

DETROIT DIESEL ALLISON COOLING FANS

Page No.	Fan Part No. GM	Blade Description Dia. - Blades x Projected Width	Used As				(1) Drive Ratio	(2)	Characteristic Curve Number	Model Usage
			Blwr.		Suct.				(3) Performance	
			R. H.	L. H.	R. H.	L. H.				
1	5128457	14 - 6 x 1.34	*			*	1.25	1	F1-0000-00-46	2-53
1	5128457	14 - 6 x 1.34	*			*	1.70	2	F1-0000-00-46	2-53
2	5146844	17 - 6 - 1.75		*	*		1.25	2	F1-0000-00-47	53
2	5146844	17 - 6 - 1.75		*	*		1.0	1	F1-0000-00-47	53
2	5146845	17 - 6 - 1.75	*			*	1.25	2	F1-0000-00-47	53
2	5146845	17 - 6 - 1.75	*			*	1.0	1	F1-0000-00-47	53
4	5112830	18 - 6 - 2.38	*			*	1.54	7	F1-0000-00-54	2-71
4	5145773	18 - 6 - 2.38	*			*	1.25	4	F1-0000-00-54	53, 71
4	5147710	18 - 6 - 2.38	*			*	1.25	4	F1-0000-00-54	53, 71
3	5147711	18 - 6 - 2.38	*			*	1.54	5	F1-0000-00-52	2-71
5	5145211	20 - 6 - 2.27	*			*	1.00	3	F1-0000-00-56	53, 71
5	5145212	20 - 6 - 2.27	*			*	1.00	3	F1-0000-00-56	53, 71
6	5100158	22 - 5 x 2		*	*		1.0	15	F1-0000-00-58	4-53
6	5119011	22 - 5 x 2		*	*		1.25	17	F1-0000-00-58	3, 4-53
6	5119011	22 - 5 x 2		*	*		1.0	15	F1-0000-00-58	3, 4-53
6	5119014	22 - 5 x 2	*			*	1.0	15	F1-0000-00-58	3, 4-53
7	5119012	22 - 5 x 2 3/4		*	*		1.0	16	F1-0000-00-59	3, 4-53
7	5119013	22 - 5 x 2 3/4	*			*	1.0	16	F1-0000-00-59	3, 4-53
7	5145904	22 - 5 x 2 3/4	*			*	1.0	16	F1-0000-00-59	53
7	5162837	22 - 5 x 2 3/4		*	*		1.0	16	F1-0000-00-59	53
20	5173871	22 - 6 x 2 1/4	*			*	1.1	17	F1-0000-00-73	6V-53
20	5173872	22 - 6 x 2 1/4		*	*		1.1	17	F1-0000-00-73	6V-53
8	3292286	22 - 6 x 2 3/8	*			*	1.25	8	F1-0000-00-60	3, 4, 6-71
8	3223656	22 - 6 x 2 3/8		*	*		1.3	9	F1-0000-00-60	4-71
9	5124701	24 - 6 x 2 3/8		*	*		1.25	10	F1-0000-00-61	4-53
9	5128508	24 - 6 x 2 3/8		*	*		1.25	10	F1-0000-00-61	6V-71
9	5100183	24 - 6 x 2 3/8	*			*	1.1	7	F1-0000-00-61	6V-53
9	5140100	24 - 6 x 2 3/8	*			*	1.0	6	F1-0000-00-61	3,4-53,3,4-71
28	5139962	24 - 6 x 2.50			*		1.0	6	F1-0000-00-90	6-71
16	5173429	26 - 4 x 2 3/8		*	*		1.25	10	F1-0000-00-62	3,4-71, V71
11	5173430	26 - 4 x 2 1/2	*			*	1.25	10	F1-0000-00-63	3, 4-71
12	5171228	26 - 6 x 2 3/4		*	*		1.25	12	F1-0000-00-64	71, V-71, 6V-53, 8V-53

(1) Fan Speed - Engine Speed x Drive Ratio.
(2) Under this number horsepower is on curve No. F1-0000-00-45, Sheet 1 & 2.
(3) Air Delivery at Fan RPM.

FAN CHARACTERISTICS
22 INCH - 5 BLADE x 2 INCH PROJECTED WIDTH
PROBABLE INSTALLATION PERFORMANCE

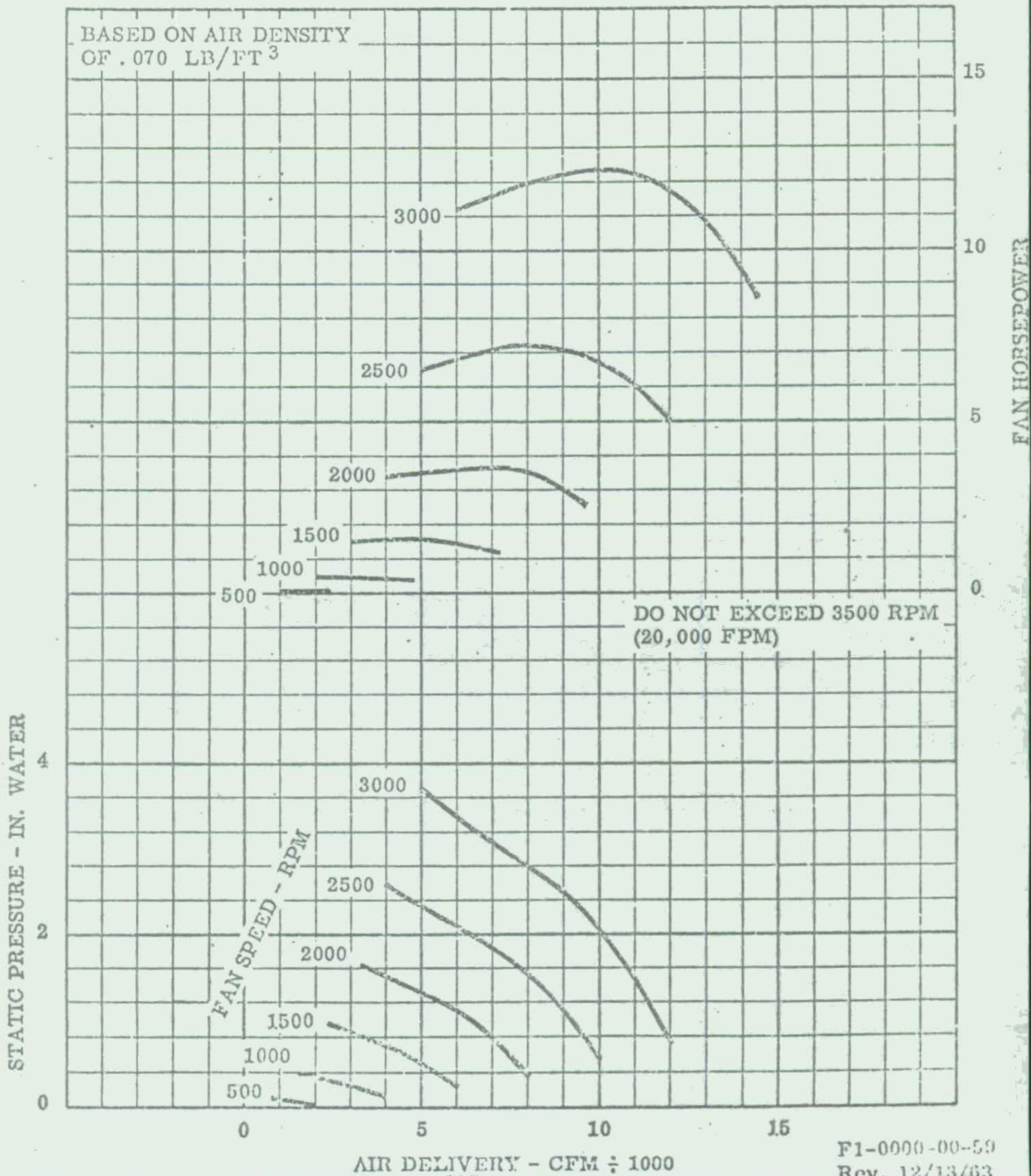


F1-0000-00-58
Rev. 12/13/63

DETROIT DIESEL ENGINE DIVISION

GENERAL MOTORS CORPORATION

FAN CHARACTERISTICS
22 INCH - 5 BLADE x 2 3/4 INCH PROJECTED WIDTH
PROBABLE INSTALLATION PERFORMANCE



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Rev. 12/13/63

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY

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DATE

ORDER NO. ATLAS

PAGE 1 OF

REPORT NO.

ENGINE

DETROIT DIESEL 4V-53N 33.0 BTU/MIN/HP
140 HP = 4620 BTU/MIN

TRANSMISSION

CLARK 5-SPEED 96% EFF IN LOW

HYDRAULIC SYSTEM

15 HP @ 50% EFF. 318 BTU/MIN

COOLANT FLOW

RPM	FLOW (GPM)
1200	24
2800	59

TOTAL HEAT REJECTION 4938 BTU/MIN

AMBIENT AIR TEMP = 125 °F

WATER TEMP TO RADIATOR = 220 °F

LIMIT 230 °F

PACIFIC CAR AND FOUNDRY COMPANY

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DATE ____________ REPORT NO. ____________

MASS FLOW OF COOLANT @ 220°F

$\rho_{H_2O} = 59.5 \ lb/FT^3 = 7.97 \ \frac{lb}{GAL}$

ΔT COOLANT = $(4938)/(7.97)(59)(1.0)$

ΔT COOLANT = 10.5°F

MAXIMUM AIR TEMP = COOLANT MINIMUM TEMP MINUS 15°F

MAX. AIR TEMP = 210 - 15 = 195°F

ΔT AIR = 195 - 125 = 70°F

$\dot{m}_{AIR} = 4938/(.241)(70) = 293$ lb/MIN

@ 195°F $\rho_{AIR} = .060$ lb/FT^3

REQUIRED CFM = 293/.060 = 4855

RADIATOR CORE SIZE ALLOCATED:

$24 \times 24 = 576\ IN^2 = 4.00\ FT^2$

FACE VELOCITY $= 4883/4.0 = 1220 \frac{FT}{MIN}$

CORRECTED TO STD AIR (SFPM) =

$1220 \left(\frac{530}{655}\right) = 988$

ASSUME SFPM = 1000

MTD = 215 - 125 = 90 °F

$q_{RAD} = (K)(A)(MTD) = (14.0)(4.0)(90)$

$q_{RAD} = 5050$ BTU/MIN (NEGLECTING TUBE VELOCITY CORRECTION)

4938 BTU/MIN REQUIRED.

PACIFIC CAR AND FOUNDRY COMPANY

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PAGE 4 OF

REPORT NO.

FOR 1000 SFPM FACE VELOCITY IS

$1000 \frac{655}{530} = 1240$ FT/MIN

CFM = (1240)(4) = 4950

FOR .75 % FAN EFFICIENCY:

CFM = 4950/.75 = 6600 CFM

FAN REQUIREMENT IS 6600 CFM @ "X" INCHES H_2O

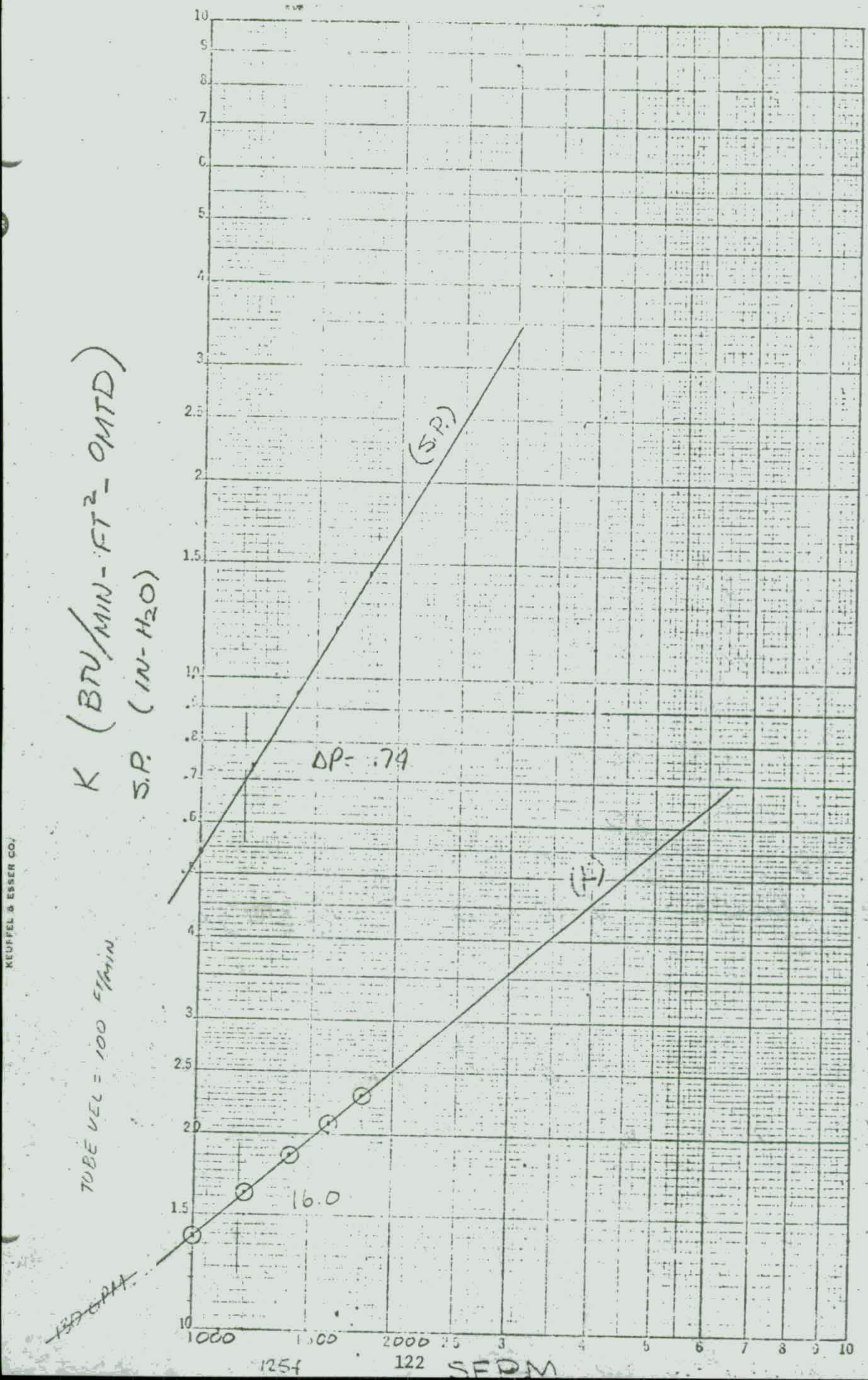
ΔP ESTIMATE: RADIATOR @ 1240 FT/MIN .75

SYSTEM TOTAL 2.75 IN H_2O

24" SCHWITZER # 24201 w/VENTURI @ 2800 RPM: 7000 CFM @ 2.75 IN-H_2O

Hp = 6.8

6-ROW
CORE

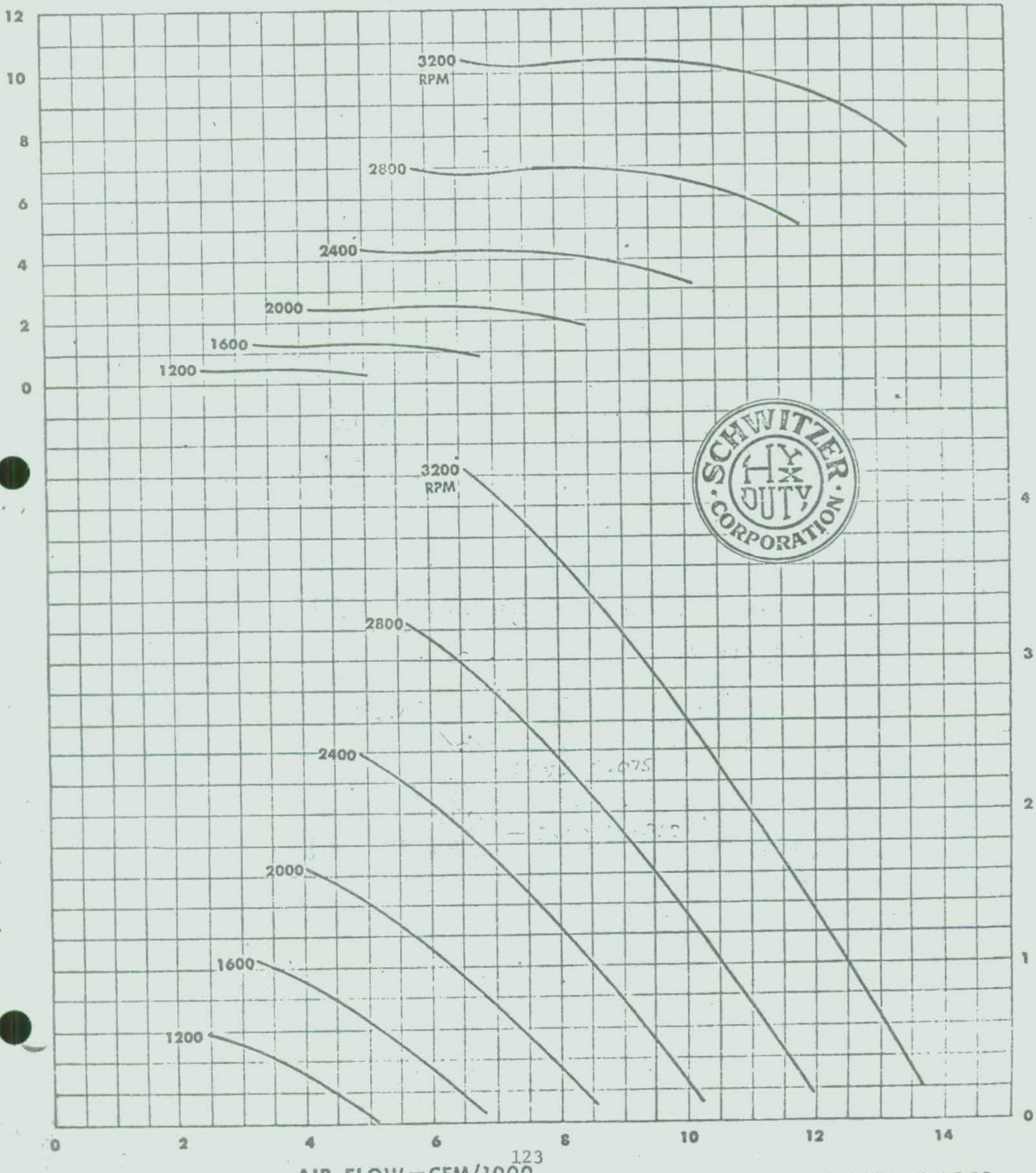

K (BTU/MIN-FT²-OMTD)
S.P. (IN-H2O)
(S.P.)
ΔP= .79
(F)
16.0
TUBE VEL = 100 FT/MIN
130 GPM
1254
122
SFPM
KEUFFEL & ESSER CO.

SCHWITZER CORPORATION

24 inch Fan Diameter

Performance in venturi shroud

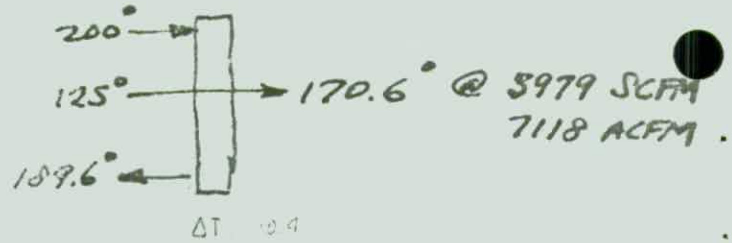
Standard Air Density .075



CURVE

FLBBB* 17:09CST 11/16/73

"ATLAS"
D 235552
STEVE BLACK, [illegible]



INPUT?0

PRI?4940,59.0,200,125,0,2,0
)
SEC?4.2,2.19,1,24,0,0
S
TER?32,1,1
)

Q= 4940 GPM= 59 PERGLY= 0 $\boxed{\text{TTI=200.0 TAMB=125.0}}$ ALT= 0 PP= 2.0 ADM=0

FA= 4.2 LEN= 2.2 FANS=1 DIA= 24 MXHP= 0 MXDPT= 0.

CC=32 NPCR=1 NPCO=1 NT= 260 VT= 79
AAH115 5 ROW CORE 4 7/16" FIN WIDTH (SEE 0235552.)

TTOUT	TAOUT	HP	SFPM	SCFM	SSP	ACFM	TF	EE	DPT	U	CORR	LMTD	CF
189.6	170.6	1	1423	5979	0.86	6673	0.1	0.0	0.6	27	0.99	44.7	.964

INPUT?3 σ = 0.84 DENSITY RATIO AT SUCKER FAN

TER?4,1,1 $\frac{5979}{0.84} = 7118$ ACFM

CC= 4 NPCR=1 NPCO=1 NT= 312 VT= 66
AAH116 6 ROW CORE 5 5/16" FIN WIDTH

TTOUT	TAOUT	HP	SFPM	SCFM	SSP	ACFM	TF	EE	DPT	U	CORR	LMTD	CF
189.6	175.3	1	1291	5424	0.83	6054	0.1	0.0	0.6	29	0.98	41.5	.956

INPUT?@

USED .22 UNITS
BYE
0000.25 CRU 0000.06 TCH 0000.84 KC

OFF AT 17:12CST 11/16/73
@

FLBBB*   17:27CST   11/16/73

ATLAS
D235552
STEVE BLACK, PACCAR

INPUT? 0

PRI? 4940, 59, 0, 210, 125, 0, 2, 0
S
SEC? 4.2, 2.19, 1, 22, 0, 0
)
TER? 32, 1, 1
S

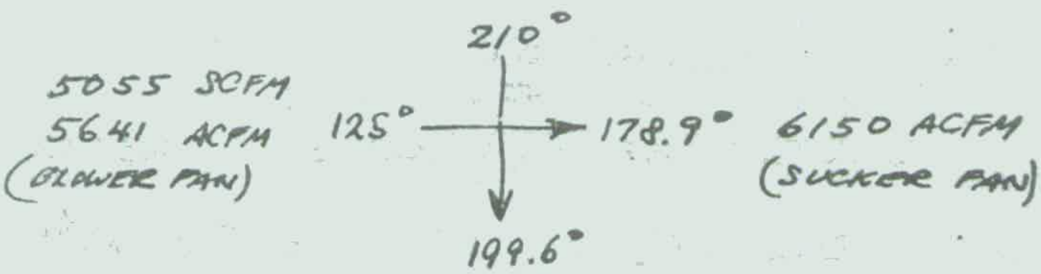
Q=   4940 GPM=   59 PERGLY= 0 TTIN=210.0 TAMB=125.0 ALT=   0 PP= 2.0 ADM=0

FA=   4.2 LEN= 2.2 FANS=1 DIA= 22 MXHP=   0 MXDPT= 0.

CC=32 NPCR=1 NPCO=1 NT= 260 VT= 79
AAH115

TTOUT	TAOUT	HP	SFPM	SCFM	SSP	ACFM	TF	EE	DPT	U	CORR	LMTD	CF
199.6	178.9	1	1203	5055	0.65	5641	0.1	0.0	0.6	24	0.99	49.7	.963

INPUT?



3

TER? 4.-, 1, 1

CC= 4 NPCR=1 NPCO=1 NT= 312 VT= 66
AAH116

TTOUT	TAOUT	HP	SFPM	SCFM	SSP	ACFM	TF	EE	DPT	U	CORR	LMTD	CF
199.6	184.0	1	1100	4623	0.63	5160	0.1	0.0	0.5	26	0.98	46.1	.954

INPUT? 4

PROGRAM STOP AT 2520

USED   .22 UNITS
BYE
0000.25   CRU   0000.03   TCH   0000.87   KC

OFF AT 17:29CST 11/16/73

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REPORT NO.

AXLE LOADS

FROM PRELIMINARY WEIGHT & C.G. STUDY

TOWING HOWITZER
DRIVE AXLE LOAD = 17,000#
STEER AXLE - UNLOADED

SOLO OPERATION
DRIVE AXLE LOAD = 9600#
STEER AXLE LOAD = 4800#

MAX DRAWBAR PULL = 13,500#

MAX BRAKING FORCE
DRIVE AXLE / W HOWITZER = 11,000#
STEER AXLE / SOLO = 4,790#

MAX DRIVE AXLE LOAD
PANIC STOP W/HOWITZER = 21,200#

MAX STEER AXLE LOAD
PARKED UPHILL ON 20° SLOPE = 7980#

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REPORT NO.

TORSION BAR SUSPENSION
DRIVE AXLE
FOR 12" TOTAL TRAVEL (6 UP, 6 DOWN)

@ 8250# WHEEL LOAD

TORQUE = 8250 × 25 IN (FROM LAYOUT) = 206,300 LB-IN

$\phi = 16°$

@ MAX TRAVEL @ $\phi = 31°45'$

MAX TORQUE = 206,300 (31.75)/16 = 409,000 LB-IN

MAX WHEEL LOAD = 409000/25.38 = 16,130#

WITH 140 KSI SHEAR LIMIT
(SHOTPEENED & PRESET)

$$d = \sqrt[3]{\frac{16\,T}{\pi S_s}} = \sqrt[3]{\frac{16\,(409,000)}{\pi\,(140000)}} = 2.46\text{ IN}$$

$$L = \frac{\phi G d^4}{584\,T} = \frac{31.75\,(11 \times 10^6)(2.46)^4}{584\,(.409 \times 10^6)}$$

$= 53.5''$

@ SOLO NOMINAL STATIC LOAD (8900#)

MOMENT = 8900 (15) = 133,500 LB-IN

WINDUP ANGLE = $\frac{133,500}{206,300} \times 16° = 10.30°$

CHECK - FOR ACTIVE LENGTH = 54.82 & d = 2.46

$$\phi = \frac{\pi S_s L\, 584}{16 G d} = \frac{\pi (140,000)(54.82)(584)}{16 (11 \times 10^6)(2.46)} = 32.52°$$

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DATE 10/3/73 | REPORT NO.

TORSION BAR PRESET

RECOMMENDED PRESET IS .022 STRAIN

FOR LARGE BAR THIS IS

$$\gamma = \frac{\phi^{(RAD)} d}{2L}$$

$$\phi = \frac{2\gamma L}{d} = 114.6\frac{\gamma L}{d} = \frac{114.6(.022)(53.5)}{2.46}$$

$$= 54.8^\circ$$

FOR SMALL BAR

$$\phi = 114.6\frac{\gamma L}{d} = \frac{114.6(.022)(40.7)}{1.275} = 80.5^\circ$$

MAXIMUM SET ANGLE DURING PRESETTING (.008 STRAIN)

LARGE BAR $\frac{8}{22}(54.8) = 19.9^\circ$

SMALL BAR $\frac{8}{22}(80.5) = 29.25^\circ$

MAX ALLOWABLE SET DURING ENDURANCE TEST = 10% OF MAX ALLOWABLE TWIST

LARGE BAR = 10% (31°45') = 3°

SMALL BAR = 10% (46°25') = 4.5°

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PAGE OF

REPORT NO.

TORSION BAR SERRATIONS

MAJOR DIA = 1.2 + (BAR DIA)
LENGTH = .4 (MAJOR DIA)

LARGE BAR

SMALL END
MAJ DIA REQD ≥ 1.2(2.46) = 2.95
USE 16/32 SIDE FIT FILLET ROOT
49 TOOTH 3.1250 MAJ DIA. ←
LENGTH = .4(3.1250) = 1.25
USE 1.25 ←

LARGE END
USE 16/32 SIDE FIT FILLET ROOT
51 TOOTH 3.2500 MAJ DIA ←
LENGTH - 1.300
USE 1.312 ←

~~SMALL BAR~~

~~SMALL END~~
~~MAJ DIA REQD ≥ 1.2(1.275) = 1.56~~
~~USE 16/32 SIDE FIT FILLET ROOT~~
~~26 TOOTH MAJ DIA 1.6250 ←~~
~~LENGTH = .4(1.625) = .6500~~
~~USE .68 ←~~

~~LARGE END~~
~~USE 16/32 SIDE FIT FILLET ROOT~~
~~28 TOOTH MAJ DIA 1.7500 ←~~
~~LENGTH = .4(1.7500) = .75 ←~~

USE COILS

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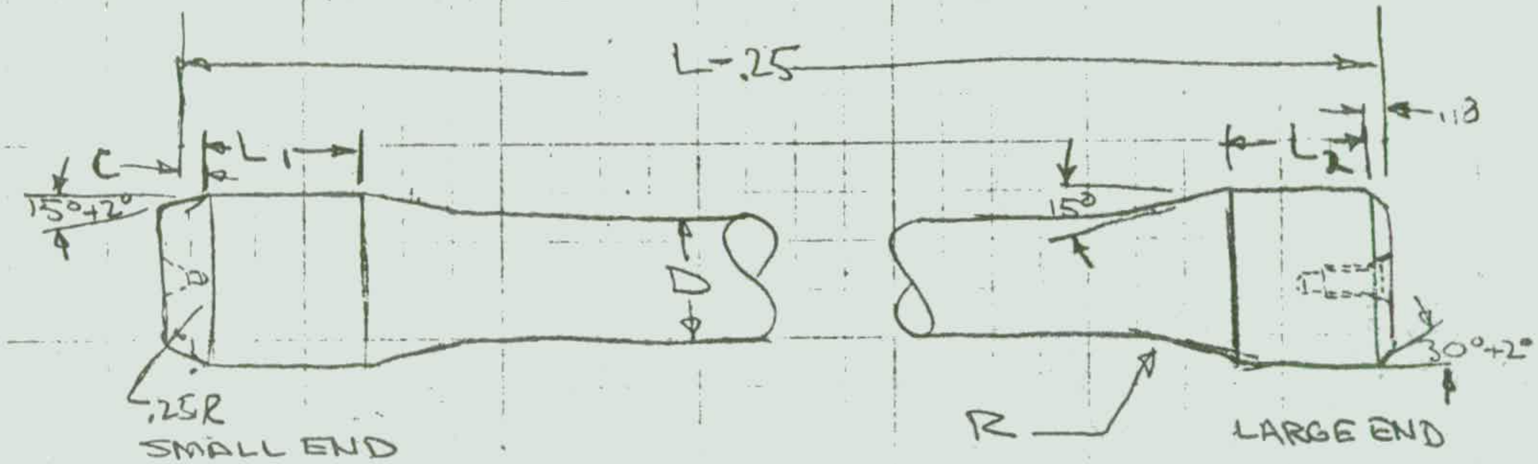
DATE

ORDER NO.
PAGE OF
REPORT NO.



	-1	-2	~~-3~~	-4
LENGTH L	59.88	59.88	~~44.50~~	44.50
L_1	1.25	1.25	~~.68~~	.68
L_2	1.31	1.31	~~.75~~	.75
C	.88	.88	~~.62~~	.62
BAR DIA D	2.460+.020	2.460+.020	~~1.275+.010~~	1.275±.010
BLEND RAD. R	4.0	4.0	~~2.0~~	2.0
PRESET (X°)	CC 54.8°	CW 54.8°	~~CC 80.5°~~	CW 80.5°
MAX PERMANENT SET (Y°)	19.9°	19.9°	~~29.25°~~	29.25°
MAX WINDUP ANGLE	31°45'	31°45'	~~46°25'~~	46°25'
MAX ALLOWABLE SET DURING FATIGUE TEST	3°	3°	~~4.5°~~	4.5°

Use coils

42.7 31

55 .83

62 10

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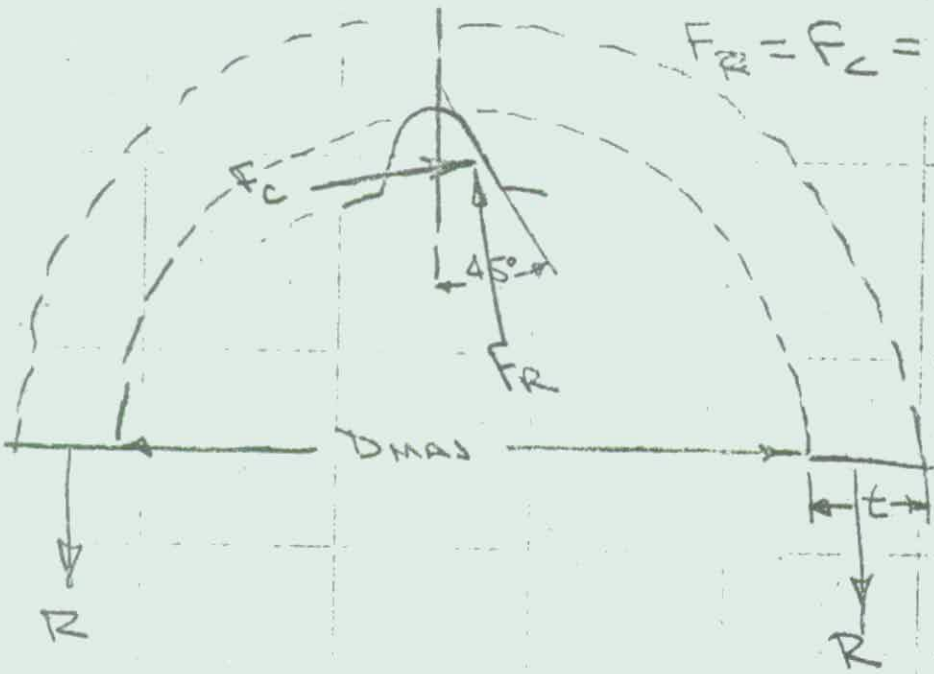
ORDER NO.
PAGE OF
REPORT NO.

TORSION BAR ANCHOR INTERNAL SERRATION RADIAL FORCE



$$F_R = F_C = \frac{T_{MAX}}{N} \Big/ R_P$$

$T_{MAX} = 55200$ LB-IN
$N = 26$ TEETH
$R_P = 1.5625/2$

$D_{MAJ} = 1.6500$

$$R = F_R D_{MAJ}$$

$$\sigma = \frac{F_R D_{MAJ}}{2t} = \frac{T_{MAX} D_{MAJ}}{N R_P 2t}$$

FOR $\sigma = 100{,}000$ PSI W/FS=2 ($\sigma_{ALL} = 50{,}000$)

$$t = \frac{T_{MAX} D_{MAJ}}{N R_P 2 \sigma} = \frac{55{,}200(1.65)}{26(.7813)(2)(50{,}000)}$$

$= .0272$ IN

USE .25 PLUS

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DATE 10/9/73

ORDER NO.

PAGE 1 OF

REPORT NO.

TORSION BAR

WHEEL LOAD VS WHEEL TRAVEL

DRIVE AXLE

TORSION BAR TORQUE @ NOM STATIC LOAD

$T_N = 8250 \times 25 = 206,000$ LB-IN

@ $\theta = 16°$

T_{MAX} @ $\theta = 31°45' = 409,000$ LB-IN

	FROM WHEEL MOM ARM (LAYOUT)	WHEEL LOAD #	WHEEL TRAVEL
$T_{2°30'} = 31,800$ LB-IN	23.36	1360#	-4.75
$T_{8°30'} = 114,600$ "	24.12	4625#	-2.88
$T_{13°30'} = 174,000$ "	24.75	7025#	-1.0
$T_{23°30'} = 302,700$	25.38	11920#	+2.88
$T_{31°45'} = 408,700$	25.44	16050#	+6.12

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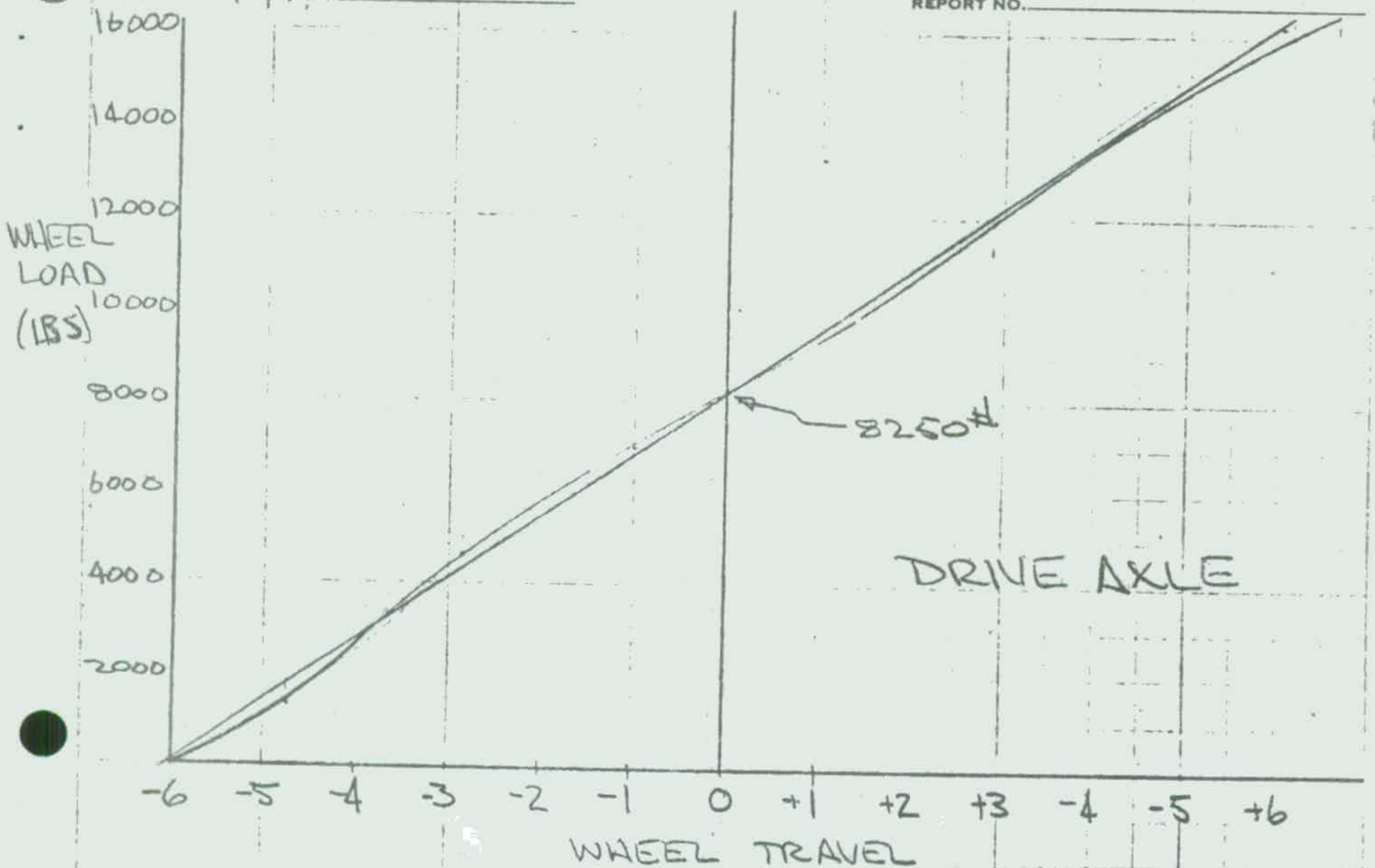
PAGE: 2 OF

REPORT NO.



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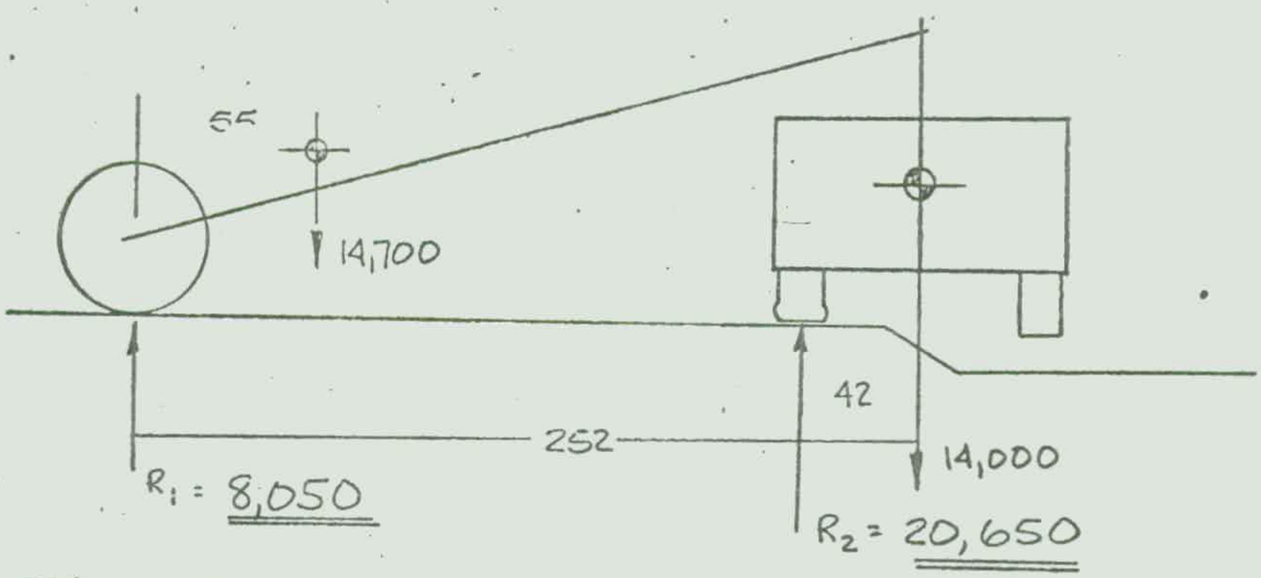
DATE ______ REPORT NO. ______



$\Sigma M_{R_1} = 0$

$\therefore (55)(14,700) + (252)(14,000) - 210(R_2) = 0$

$R_2 = 20,650$

$R_1 = 28,700 - 20,650 = 8050$

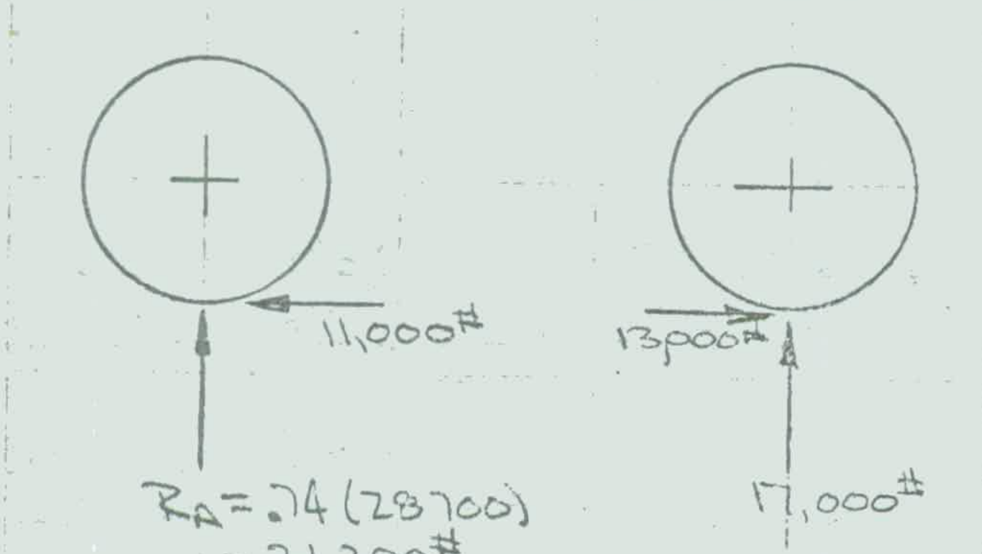
WHEEL WILL BOTTOM OUT

PCF-RN-597

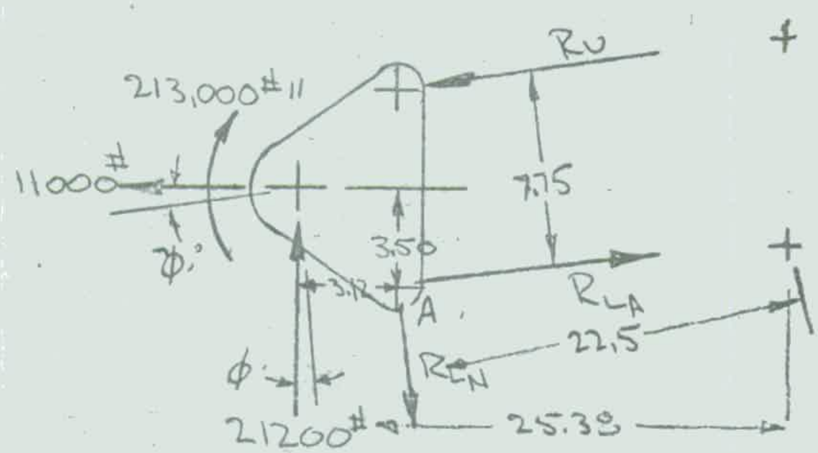
DRIVE AXLE SUSPENSION LOADS

1. BRAKING
.5G FROM 35MPH

2. MAX DBP
BACKING UP 50% SLOPE



AT WHEELS
(WORST LOAD IS COND. 1.)



AT AXLE — SUSPENSION ARM JOINT

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CHECKED BY

PAGE 2 OF

DATE 9/28/73

REPORT NO.

FOR AXLE LOAD OF 21,200#

TOTAL SUSP ARM TRAVEL = 31.75° @ 411,000 LB-IN

$$\text{TRAVEL @ } 21200 = \frac{31.75}{411{,}000} \times \frac{21200}{2} \times 25.38$$

$$= 20.8°$$

WITH SUSP RELAXED ARM IS 28.5° BELOW HORIZONTAL

SO AT 21,200# AXLE LOAD

$$\phi = 28.5 - 20.8 = 7.7°$$

TAKING MOMENTS AT A

$$6.75\, R_U + 3.5(11000) = 213000 + 3.12(21200)$$

$$R_U = \frac{213000 + 65200 - 38500}{7.75}$$

$$= \underline{\underline{30{,}900}}\ \text{\#}$$ (TOTAL FOR BOTH WHEELS)

$$\Sigma F_x = 0$$

$$R_{LA} = R_U + 11{,}000(\cos 7.7°) - 21{,}200(\sin 7.7°)$$

$$= 30900 + 11890 - 2840$$

$$= \underline{\underline{39{,}950}}\ \text{\#}$$ (TOTAL FOR BOTH WHEELS)

$$R_{LN} = \frac{\text{TORSION BAR MOMENT}}{\text{SUSP ARM LENGTH}}$$

$$= \frac{21{,}200\,(25.38)}{22.50} = \underline{\underline{23{,}930}}\ \text{\#}$$

(TOTAL FOR BOTH WHEELS)

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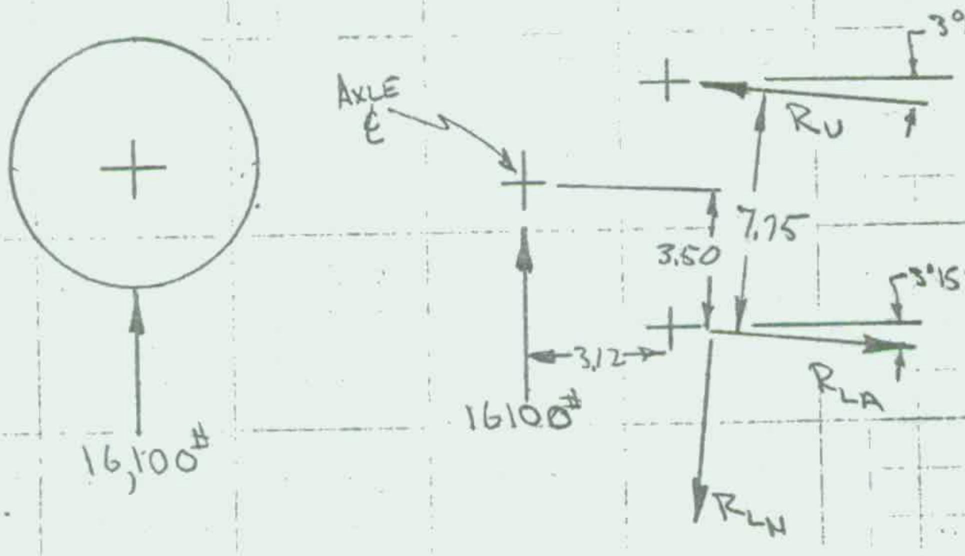
DATE 10/31/73 REPORT NO.

3. LOADS AT MAX SPRING TRAVEL



NEGLECTING EFFECT OF SMALL ANGLE

$$R_U = \frac{16100(3.12)}{7.75} = \underline{\underline{6500^{\#}}}$$

$$R_{LA} = \underline{\underline{6500^{\#}}}$$

R_{LN} = T-BAR TORQUE/ARM LENGTH

$$= 409{,}000/22.5 = \underline{\underline{18{,}200^{\#}}}$$

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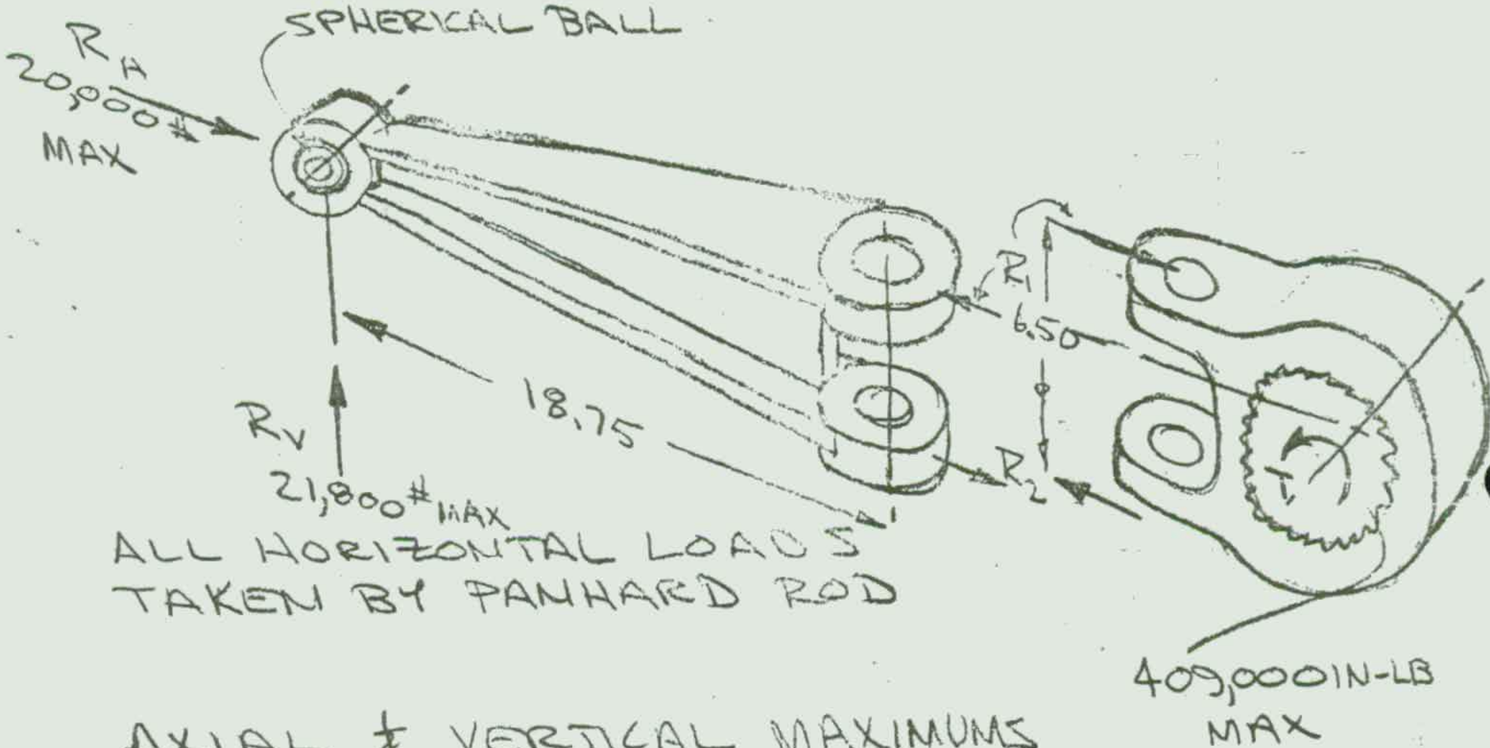
PAGE 1 OF

REPORT NO.

SUSPENSION ARM - DRIVE AXLE



ALL HORIZONTAL LOADS TAKEN BY PANHARD ROD

AXIAL & VERTICAL MAXIMUMS DON'T OCCUR AT SAME TIME

COND 1. $R_A = 20{,}000\#$, $R_V = 12{,}000\#$, $T = 225{,}000\#$

COND 2. $R_A = 6500\#$, $R_V = 21{,}800\#$, $T = 409{,}000$ LB-I

CHECK COLUMN BUCKLING FOR CONDITION 1.

CHECK BENDING STRESS FOR CONDITION 2.

CHECK EYE STRESS ON BOTH PARTS

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ORDER NO.

PAGE 2 OF

REPORT NO.

BENDING STRESS

CHECK @ SECTIONS ~~A - 1" from small end~~
B - 4" " " "
C - 6½ " " "
D - 17¼ " " "
E - 9.11/16 " " "

FOR .38 THICK FLANGES & .25 THK WEB

$$I_B = \frac{.25(3.25)^3}{12} + 2\left[\frac{(1.312)(.38)^3}{12} + (1.312)(.38)(1.813)^2\right]$$

$$= 1.03 + 2[.056 + 1.635] = 4.412 \text{ IN}^4 \leftarrow$$

$$I_C = \frac{.25(3.75)^3}{12} + 2\left[\frac{(1.625)(.38)^3}{12} + 1.625(.38)(2.063)^2\right]$$

$$= 1.10 + 2[.0714 + 2.59] = 6.323 \text{ IN}^4 \leftarrow$$

$$I_D = \frac{.25(5.813)^3}{12} + 2\left[\frac{3.04(.38)^3}{12} + 3.063(.38)(3.09)^2\right]$$

$$= 4.09 \quad + 2[.1347 + 10.96] = 26.28 \text{ IN}^4 \leftarrow$$

$$I_E = \frac{.25(4.313)^3}{12} + 2\left[\frac{2.03(.38)^3}{12} + 2.03(.38)(2.344)^2\right]$$

$$= 1.668 + 2[.0893 + 4.18] = 10.21 \text{ IN}^4 \leftarrow$$

MAX BENDING & AXIAL STRESS COMBINED
SECTION B

$$\sigma_{MAX} = \frac{4(21,800)(2)}{4.412} \pm \frac{6500}{3.25(.25) + 2(1.312)(.375)}$$

$$= 39,500 \text{ psi} \pm 3600 \text{ psi} \quad = 35,900 \text{ TENSION}$$
$$43,100 \text{ COMPRESS}$$

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CHECKED BY

DATE 1-28-74

ORDER NO.

PAGE 3 OF

REPORT NO.

SECTION C

$$\sigma_{MAX} = \frac{6.5(21.800)(2.25)}{6.323} \pm \frac{6500}{.25(3.75)+2(1.625)(.375)}$$

$$= 50,400 \pm 3000 = \begin{array}{l} 47,400 \text{ psi TENSION} \\ 53,400 \text{ psi COMP} \end{array}$$

SECTION E

$$\sigma_{MAX} = \frac{9.688(21,800)(2.524)}{10.21} \pm \frac{6500}{.25(4.313)+2(2.03)(.375)}$$

$$= 52,300 \pm 2500 = \begin{array}{l} 49,800 \text{ psi TENS} \\ 54,800 \text{ psi COMP} \end{array}$$

SECTION D

$$\sigma_{MAX} = \frac{17.25(21,800)(3.27)}{26.28} \pm \frac{6500}{.25(5.813)+2(3.063)(.375)}$$

$$= 48,600 \pm 1700 = \begin{array}{l} 46900 \text{ psi TENS} \\ 50300 \text{ psi COMP} \end{array}$$

PLOTTING BENDING STRESS VS DIST, FROM LOAD SHOWS THE VALUE AT SECTION E TO BE VERY NEARLY THE MAXIMUM

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PREPARED BY HYK
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DATE 1-22-74

ORDER NO.
PAGE 4 OF
REPORT NO.

COLUMN BUCKLING

FIRST APPROXIMATION:
ASSUME STRAIGHT I BEAM WITH I = I @ SEC E
HINGED AT BOTH ENDS

$$A = 2.59 \text{ IN}^2$$

$$I = \frac{\cancel{4.315}(.25)^3}{12} + 2\left(\frac{.38(2.03^3)}{12}\right)$$

$$= .262 \text{ IN}^3$$

$$r = \sqrt{I/A} = \sqrt{.262/2.59} = .318 \text{ IN}$$

$$L/r = 18.15/.318 = 59.0$$

SHORT COLUMN

BUCKLING IN HORIZONTAL PLANE (FROM AXIAL LOAD ONLY)

$$\frac{P}{A} = S_y - 1.172(L/r)^2$$ NEED $S_y \approx 115000$ psi FOR BENDING

$$P = A[S_y - 1.172(L/r)^2]$$

$$= 2.59(115{,}000 - 1.172(59)^2] = 287{,}000\#$$

BUCKLING IN VERTICAL PLANE
WON'T BUCKLE UNTIL BENDING & DIRECT COMPRESSION STRESS EXCEDE YIELD STRESS

$$\sigma_B + \sigma_c = \frac{9.688(12000)(2.524)}{10.21} + \frac{20000}{2.59}$$

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DATE 1-28-74

ORDER NO.

PAGE 5 OF

REPORT NO.

$\sigma_B + \sigma_C = 28{,}700\ psi + 7{,}730\ psi$

@ $\sigma_y = 115{,}000\ psi$ Arm won't Buckle

EYE LOADS & STRESS - ARM

@ MAX TORQUE IN TORSION BAR

$R_1 = R_2 = 409{,}000/6.50 = 63{,}000\#$

FROM H. MUELLER'S WORK (PCF)

$$\sigma = K \frac{P}{(d_o - d_i)h}$$

USING K FOR .002 d_i clearance
WITH $d_i = 1.5$
$d_o = 3.375$
$K = 3.7$

$$\sigma = \frac{3.7(63{,}000)}{(3.375-1.5)(1.0)} = 124{,}200 \text{ PSI}$$

FOR $d_i = 1.875$ (TIGHT FIT BUSHING)

$K = 3.0$

$$\sigma = \frac{3.0(63000)}{(3.375-1.875)(1)} = 126{,}000 \text{ PSI}$$

1.125 THICK REDUCES TO
112,000 PSI

CAN MAKE THICKNESS 1.25 MAX

$R_1, R_2 = 409{,}000/6.75 = 60{,}700\#$

$$\sigma = \frac{3.0(60{,}700)}{(3.375-1.875)(1.25)} = 97{,}000 \text{ psi}$$

USING 4130 Q&T RHc 36-41
σ_y = 137500 psi MIN FOR 1" THICKNESS
110000 psi " " 2" "
YIELD STRESS SHOULD BE 133,000 psi

$$FS = \frac{133{,}000}{97{,}000} = 1.37$$

THIS IS ADEQUATE SINCE THE TORSION BAR TORQUE IS LIMITED BY THE BUMP STOP

EARS ON TORSION BAR FITTING

IT IS ADVANTAGEOUS TO KEEP THE CONNECTING PIN FROM HAVING BENDING APPLIED. TO DO THIS THE PIN MUST HAVE A TIGHT FIT AT THE CENTER OF THE FITTING. THEREFORE THE PAIR OF EARS MUST BE ONE SOLID BLOCK AND OBVIOUSLY THERE WILL BE NO PROBLEM WITH THE EYE STRESS.

PIN SHEAR

SHEAR LOAD = 409,000 LB-IN/5.50
= 74,500# (SINGLE SHEAR ON EACH END)

$\tau = P/A = 74{,}500 / \frac{\pi}{4}(1.5) = 63{,}200$ PSI

NEEDS 63,200/.67 × 2 (F.S.) = 189,000 psi
(TENSILE YIELD)

USE 5160 Q&T RHc 52-57 $\sigma_{y_{min}}$ = 205,000 PSI
(1.5 ROUND)

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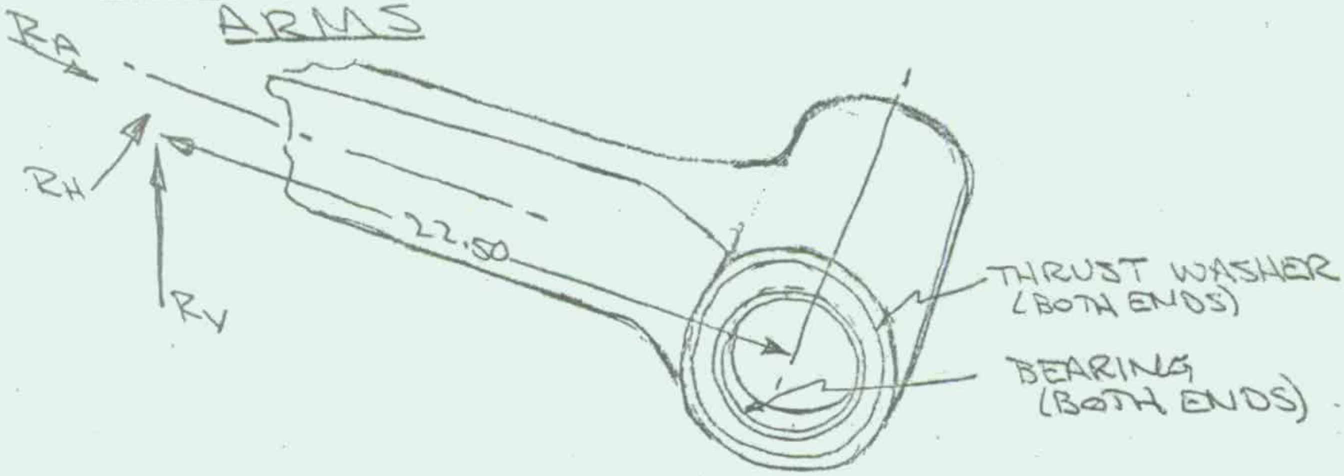
PAGE 1 OF

REPORT NO.

BEARINGS - DRIVE AXLE SUSPENSION ARMS



MIN BEARING SPREAD = 2.38 IN @ ℄s
THRUST WASHER MEAN RADIUS = 2.62

MAX LOADS	PANIC STOP	MAX AXLE TIP
R_H	0	1170#
R_V	11,965#	18,200#
R_A	19,975#	6,500#
RESULTANT RADIAL LOAD (R_R)	20,800#	19,300#

WHEN A HORIZONTAL LOAD EXISTS ASSUME 75% OF MOMENT FROM IT IS REACTED BY BEARINGS

FROM PANIC STOP

R_R = 20,800# (ON BEARINGS)

$$PSI = \frac{20800}{(4.25 + 4.50)(.75)} = 2350\ PSI \leftarrow$$

(ON PROJECTED AREA)

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FROM MAX AXLE TIP

R_R (HALF ON EACH BRG) 19,300

$$R_M = \frac{R_H(22.50)}{2.38} = \frac{1170(22.5)}{2.38} = 11{,}070^{\#}$$

(USE 75%)

TOTAL RADIAL LOAD $= R_R/2 + R_M(.75)$

$$= 9650 + 11{,}070(.75) = 17{,}940^{\#}$$

$$PSI = \frac{17940}{(4.250)(.75)} = 5510 \text{ psi}$$

(SMALLEST BRG)

THRUST WASHERS

FROM MAX AXLE TIP

$R_H = 1170^{\#}$

$$R_M = \frac{R_H(22.5)}{2(2.62)} = \frac{1170(22.5)}{2(2.62)} = 5030^{\#} \text{ (USE ONLY 25\%)}$$

ASSUMING R_M IS APPLIED TO ONLY .25 OF AREA

$$PSI = \frac{R_H}{\left(\frac{5.50+4.68}{2}\right)(.41)} + \frac{.25 R_M/2}{(.25)\left(\frac{5.50+4.68}{2}\right)}$$

$$= \frac{1170}{\frac{5.50+4.68}{2}(.41)} + \frac{.25(5030/2)}{.25\left(\frac{5.50+4.68}{2}\right)} = 6094 \text{ PSI}$$

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PAGE 3 OF
REPORT NO.

GARLOCK DU BUSHINGS HAVE ULTIMATE LOAD CAPACITY OF 20,000 PSI WITH LITTLE OR VERY SLOW MOVEMENT

THE PRESSURES CALCULATED ARE FOR WORST LOAD CONDITIONS - NORMAL OR NOMINAL STATIC GVW BEARING PRESSURES WOULD BE ON THE ORDER OF 1/4 OF THOSE CALCULATED

IF MAX WHEEL TRAVEL IS ASSUMED TO OCCUR IN .33 SEC THE SLIDING SPEED IN THE BUSHINGS IS

$$\frac{\frac{31°45\frac{1}{2}}{360°}}{.33/60} \times \frac{\pi(4.50)}{12} = 340 \text{ FPM}$$

THIS WOULD OCCUR AT AN APPROX AVERAGE PSI OF

$$\frac{\underset{\text{MAX AXLE TIP}}{5510} + \underset{\text{NOMINAL}}{\frac{5510}{4}} + \underset{\text{MAX TRAVEL NO TIP}}{\frac{5510}{2}}}{3}$$

$= 3210$ PSI

THIS WOULD PRODUCE A VERY HIGH PV (109,000) BUT THIS DOESN'T OCCUR CONTINUOUSLY, ONLY 1 CYCLE AT A TIME SO PV FACTOR HAS LITTLE MEANING

THE UNIT LOAD (PSI) IS A BETTER MEASURE AND THESE VALUES ARE ACCEPTABLE

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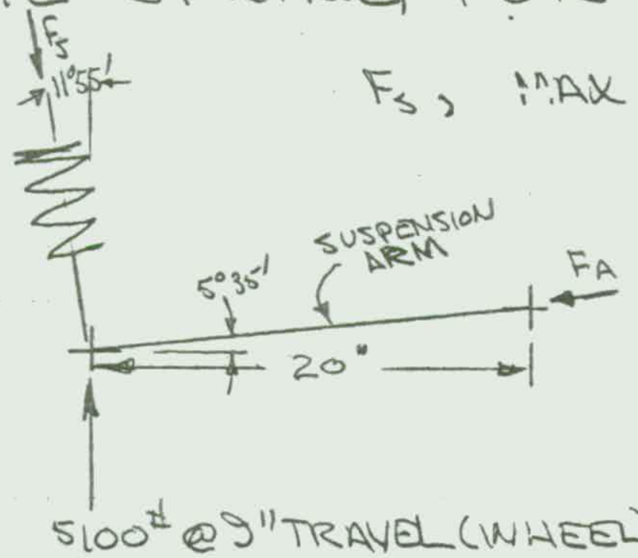
PAGE 1 OF

REPORT NO.

COIL SPRING FOR STEER AXLE



F_S, MAX SPRING FORCE

$= 5100/\cos 11°55'$

$= \underline{5210\#}$

$$F_A = \frac{F_S \sin 11°55'}{\cos 5°35'} = \frac{5210(.2065)}{.9953} = \underline{1080\#}$$

SPRING RATE = 5210/9 = 579 LB/IN

AT STATIC MAX LOAD STRESS CAN GO TO 125,000 PSI (UNCORRECTED) USING ABOUT .8 DIA WIRE, HOT COILED, PRESET ALLOY STEEL (SAE HELICAL SPRING HNDBK)
SPRING COULD BE SHOT PEENED FOR FATIGUE LIFE IMPROVEMENT

FOR 13/16 (.813) DIA ROD

$$S_S = \frac{8PD}{\pi d^3} \quad @ \; D = (5.813 - .813)$$

$$S_S = \frac{8(5210)(5.00)}{\pi(.813)^3} = \underline{123,200 \text{ PSI}} \leftarrow$$

OK

$$N(\text{ACTIVE}) = \frac{Gd^4}{8P/_\ell D^3} = \frac{11.4\times10^6(.813^4)}{8(579)(5.00^3)} = \underline{8.57} \leftarrow$$

$$\text{SOLID HEIGHT} = d(N_A + 2 - ½) = .813(8.5+2-.5)$$

$$= \underline{8.13''} \leftarrow$$

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ORDER NO.

PAGE 2 OF

REPORT NO.

$C = D/d = 5/.813 = 6.15$

K (WAHL FACTOR) $= 1.246$

$h/d = 10$, Z (ECC. FACTOR) $= 1.054$

NOMINAL WHEEL TRAVEL FOR 10^5 CYCLES $= \pm 1.5$ IN

STRESS RANGE

$$S_s = \frac{8PD}{\pi d^3} KZ \qquad P = 3(579) = 1737^{\#}$$

$$= \frac{8(1737)(5)}{\pi(.813^3)}(1.246)(1.054) = \underline{41,100 \text{ psi}}$$

THIS LOW RANGE STRESS SHOULD <u>NOT</u> REQUIRE SHOT PEENING FOR ADEQUATE FATIGUE LIFE

<u>NO</u> DECARB ON SURFACE ALLOWABLE TO MAINTAIN ALLOY ENDURANCE LIMIT

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ORDER NO.

PAGE 1 OF

REPORT NO.

STEER AXLE SUSPENSION ARM

THE SUSPENSION GEOMETRY SHOWS THAT IF ALL LINKS WERE RIGID THE ARM WOULD HAVE TO UNDERGO A MAX 12° TWIST AND A MAX 1.00 HORIZONTAL DEFLECTION WHEN THE AXLE IS AT FULL TIP. IF THE VEHICLE WERE BACKED INTO SOMETHING AND THE WHEEL HIT IT A HIGH COLUMN LOAD WOULD ALSO BE APPLIED.

THEREFORE THE TWIST & DEFLECTION MUST BE ABSORBED MOSTLY IN RUBBER MOUNTINGS, SINCE THESE CAN ALSO STORE ENERGY AND PROVIDE ROLL RESISTANCE.

THE WORST LOADING WILL BE
A COLUMN LOAD OF 4800 LB ←
(2 G x NOMINAL STATIC WHEEL LOAD)
VERTICAL LOAD OF 1345 LB ←
(REACTION OF PANIC STOP TORQUE)
COMBINED WITH 3° TWIST ←
.25 IN HORIZ DEFLECTION ←
(ASSUMING RUBBER ABSORBS 75% OF DEFLECTION AND TWIST)

Uniform Thickness = .5"

1/2

Torsion stress $\phi = 3° = .05236$ rad, $L = 16$, $G = 10{,}000{,}000$, $P = 4800$

$b/h = b_{av}/h = 2.72/.5 = 5.44$, $\beta = .294$

$$T = \frac{\phi G \beta b h^3}{L} = \frac{.05236 \times 10{,}000{,}000 \times .294 \times 2.72 \times .5^3}{16} = 3271$$

τ_{max}

at $x = 0$ $b/h = 3.4/.5 = 6.8$, $\alpha = .3016$

$$\tau_T = \frac{T}{\alpha b h^2} = \frac{3271}{.3016 \times 3.4 \times .5^2} = 12{,}759$$

$x = 16$ $b/h = 2.45/.5 = 4.9$, $\alpha = .290$

$$\tau_T = \frac{3271}{.290 \times 2.45 \times .5^2} = 18{,}415$$

Column buckling

$r_2 = .1443$, $P = 4800$, $A_{av} = 1.358$, $e = .25$

Using secant formula

$$f_a = \frac{P}{A_{av}} = \frac{4800}{1.358} = 3535$$

$$f_y' = 220{,}000 - 60{,}490 = 159{,}510$$

f.s. = 4.30508

Check - $N = f.s.$

$$f_a = \frac{f_y}{N\left[1 + \frac{ec}{r^2}\sec\left(\frac{L}{2r}\sqrt{\frac{N f_a}{E}}\right)\right]} = \frac{159{,}510}{4.30508\left[1 + \frac{.25 \times .25}{.1443^2}\sec\left(\frac{16}{2 \times .1443}\sqrt{\frac{4.30508 \times}{30{,}000{,}00}}\right.\right.}$$

$3535 = 3535$

Assume simple column

$K = .9$

$$\frac{KL}{r} = \frac{.9 \times 16}{.1443} = 99.8$$

$f_y' = 159,510$

Failure inelastic if $\frac{KL}{r} \le \sqrt{\frac{\pi^2 E}{f_y'}} = \sqrt{\frac{\pi^2 \times 30,000,000}{159,510}} = 43.1$

Since $\frac{KL}{r} > 43.1$ failure occurs elastically and is given by Euler formula

$$f_c = \frac{\pi^2 E}{(KL/r)^2} = \frac{\pi^2 \times 30,000,000}{99.8^2} = 29,728$$

$$P_c = A_{av} f_c = 1.358 \times 29,728 = 40,371$$

$$f.s. = \frac{P_c}{P} = \frac{40,371}{4800} = \underline{8.4}$$

```
0151
GHSBI      13:19   02/01/74   FRIDAY     104

1 DATA 30000000,10000000,16,.25,.05236,1345,1,6,7
11 DATA 3.4,.5,2.667
12 DATA 2.8,.5,2.667
13 DATA 2.6,.5,2.667
14 DATA 2.55,.5,2.667
15 DATA 2.5,.5,2.667
16 DATA 2.45,.5,2.667
20 DATA 0,2.667,5.333,8.0,10.667,13.334,16
100 DIM F

BREAK
RUN

GHSBI      13:20   02/01/74   FRIDAY     104
```

Segment	H	t					A	I_1	$\bar{z}_1$	$r_1=\sqrt{I_1/A}$	I_2	$\bar{z}_2$	$r_2=\sqrt{I_2/A}$
1	3.4000	0.5000	0.0000	0.0000	0.0000	0.0000	1.7000	1.6377	0.9633	0.9815	0.0354	0.1417	0.1443
2	2.8000	0.5000	0.0000	0.0000	0.0000	0.0000	1.4000	0.9147	0.6533	0.8083	0.0292	0.1167	0.1443
3	2.6000	0.5000	0.0000	0.0000	0.0000	0.0000	1.3000	0.7323	0.5633	0.7506	0.0271	0.1083	0.1443
4	2.5500	0.5000	0.0000	0.0000	0.0000	0.0000	1.2750	0.6909	0.5419	0.7361	0.0265	0.1062	0.1443
5	2.5000	0.5000	0.0000	0.0000	0.0000	0.0000	1.2500	0.6510	0.5208	0.7217	0.0260	0.1042	0.1443
6	2.4500	0.5000	0.0000	0.0000	0.0000	0.0000	1.2250	0.6128	0.5002	0.7073	0.0255	0.1021	0.1443

$H_{av} = 2.72$ $A_{av} = 1.358$ $I_{2av} = .0283$

1	5.9514E-06	3.3472E-06	4.4629E-05	3.3467E-05	5.0580E-05	2.6815E-05	3.3472E-06	2.5101E-06
2	7.2267E-06	4.0645E-06	4.3352E-05	3.2510E-05	1.9934E-04	7.3389E-05	1.4106E-05	5.5581E-06
3	7.7826E-06	4.3772E-06	3.5913E-05	2.6256E-05	4.3787E-04	1.0402E-04	3.3307E-05	8.8400E-06
4	7.9352E-06	4.4630E-06	2.3797E-05	1.7845E-05	7.4703E-04	1.2633E-04	6.1348E-05	1.2187E-05
5	8.0939E-06	4.5523E-06	1.2132E-05	9.0977E-06	1.1042E-03	1.3998E-04	9.8404E-05	1.5601E-05
6	8.2591E-06	4.6452E-06	-*********	-*********	1.4958E-03	1.4462E-04	1.4466E-04	1.9085E-05

$F_1=1345.$ $F_2=642.$ $M=4863.$ $T \approx 3271$

Point	x	σ_{F_1}	$\tau_{F_{A_v}}$	σ_{F_2}	$\tau_{F_{A_v}}$	τ_T	$\sigma_{F_1}+\sigma_{F_2}$	$\tau_{max\ shear}$	σ_{max}
1	0.	22339.	791.	38151.	377.	12,550 0.	60490.	791.	60490.
2	3.	27448.	961.	31657.	458.	0.	59105.	1061.	59105.
3	5.	25468.	1035.	18299.	494.	0.	43768.	1035.	43768.
4	8.	19857.	1055.	2550.	503.	0.	22407.	1055.	22407.
5	11.	13772.	1076.	13829.	513.	0.	27601.	1076.	27601.
6	13.	7169.	1098.	30877.	524.	0.	38046.	1098.	38046.
7	16.	0.	1098.	47636.	524.	18,415 0.	47636.	1098.	47636.

PROCESSING   2 UNITS

-153-

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PAGE OF

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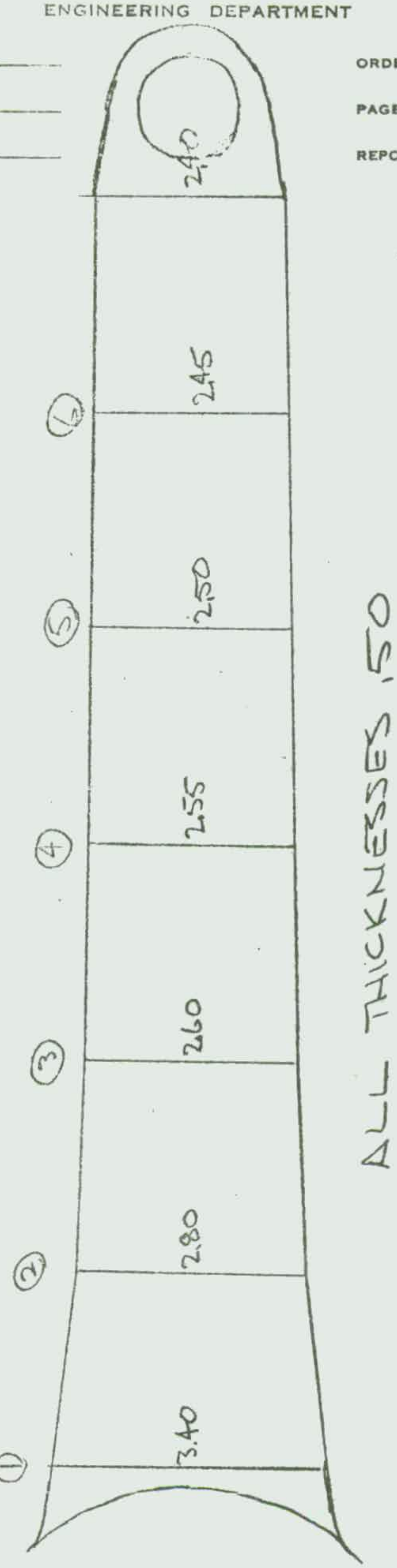

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PAGE OF

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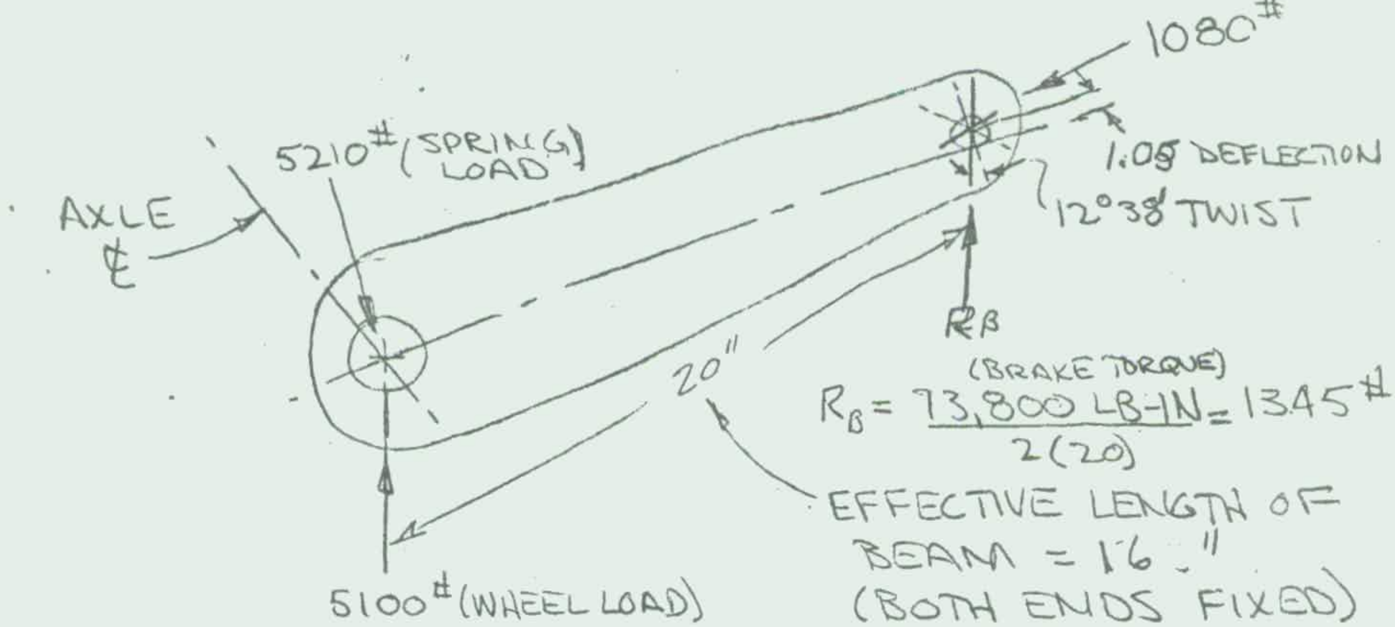
STEER AXLE
SUSPENSION ARM LOADING

WORST LOADING IS AT MAX AXLE TIP IN UPWARD DIRECTION



$$R_B = \frac{73{,}800 \text{ LB-IN}}{2(20)} = 1345\#$$

EFFECTIVE LENGTH OF BEAM = 16" (BOTH ENDS FIXED)

IF MAX BRAKING ALSO OCCURRED AT MAX AXLE TIP THE 1080# WOULD INCREASE TO 2400#
R_B OCCURS AT THIS TIME ALSO

RIVET JOINT W/AXLE

USING MS 20613 .4375 DIA RIVETS
MIN SHEAR STRENGTH (YIELD) = 25000 PSI
TORQUE PER JOINT (FROM PANIC STOP)
= 73,800/2 = 36,900 LB-IN
WITH 5 RIVETS & RIVETS IN DOUBLE SHEAR ON 2.313 R

$$FS = S_{sy}/P/A = \frac{25000}{\dfrac{36900/2.313}{5(2)(\pi/4(.4375^2))}} = 2.32$$

OK

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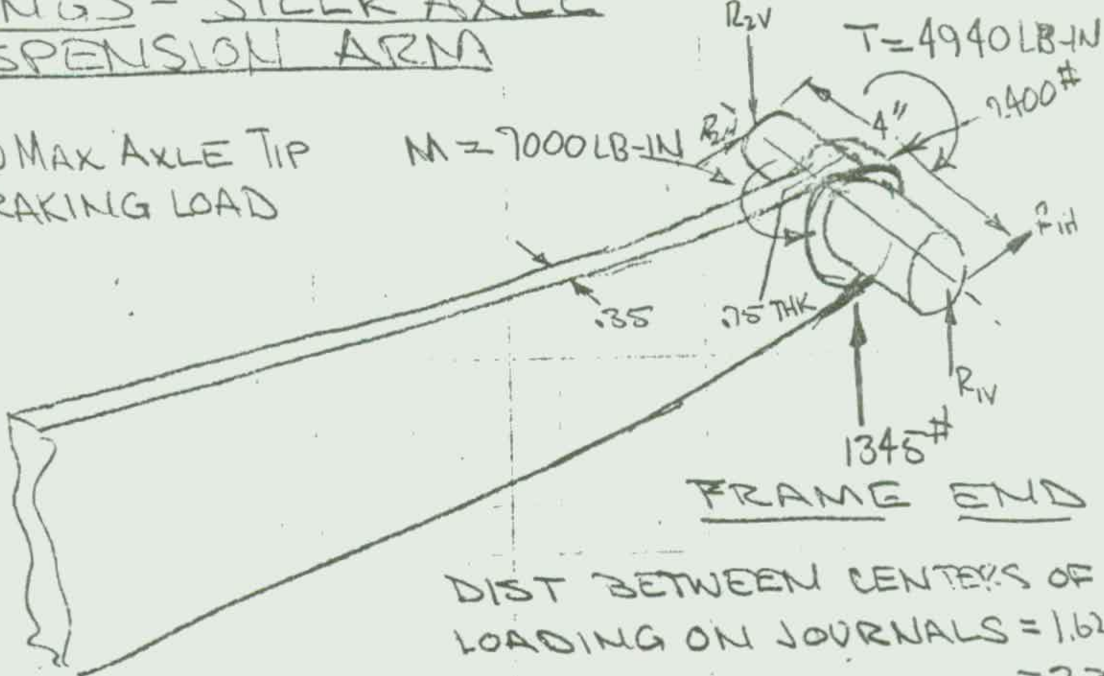
PAGE 1 OF
REPORT NO.

BEARINGS - STEER AXLE SUSPENSION ARM

LOADING @ MAX AXLE TIP W/MAX BRAKING LOAD



DIST BETWEEN CENTERS OF LOADING ON JOURNALS = 1.62+.75 = 2.37"

$$R_{1V} = R_{2V} = 4940/2.37 = 2080\#$$

$$R_{1H} = 7000/2.37 - 2400 = 460\#$$

$$R_{2H} = 7000/2.37 + 2400 = 5350\#$$

$$R_{R\,MAX} = \sqrt{R_{1V}^2 + R_{2H\,MAX}^2}$$

$$= \sqrt{2080^2 + 5350^2} = 5740\#$$

FOR THE SAME UNIT PRESSURE AS THE DRIVE AXLE ARM BUSHINGS - 5500 PSI

$$\text{JOURNAL DIA} = \frac{P}{l\ \text{PSI}} = \frac{(5740)}{1.62(5500)} = .645$$

USING $d = 1.5$ & $l = .75$

$$\text{PSI} = \frac{5740}{1.5(.75)} = 5100 \text{ PSI}$$ THIS IS COMPATABLE W/DRIVE A...

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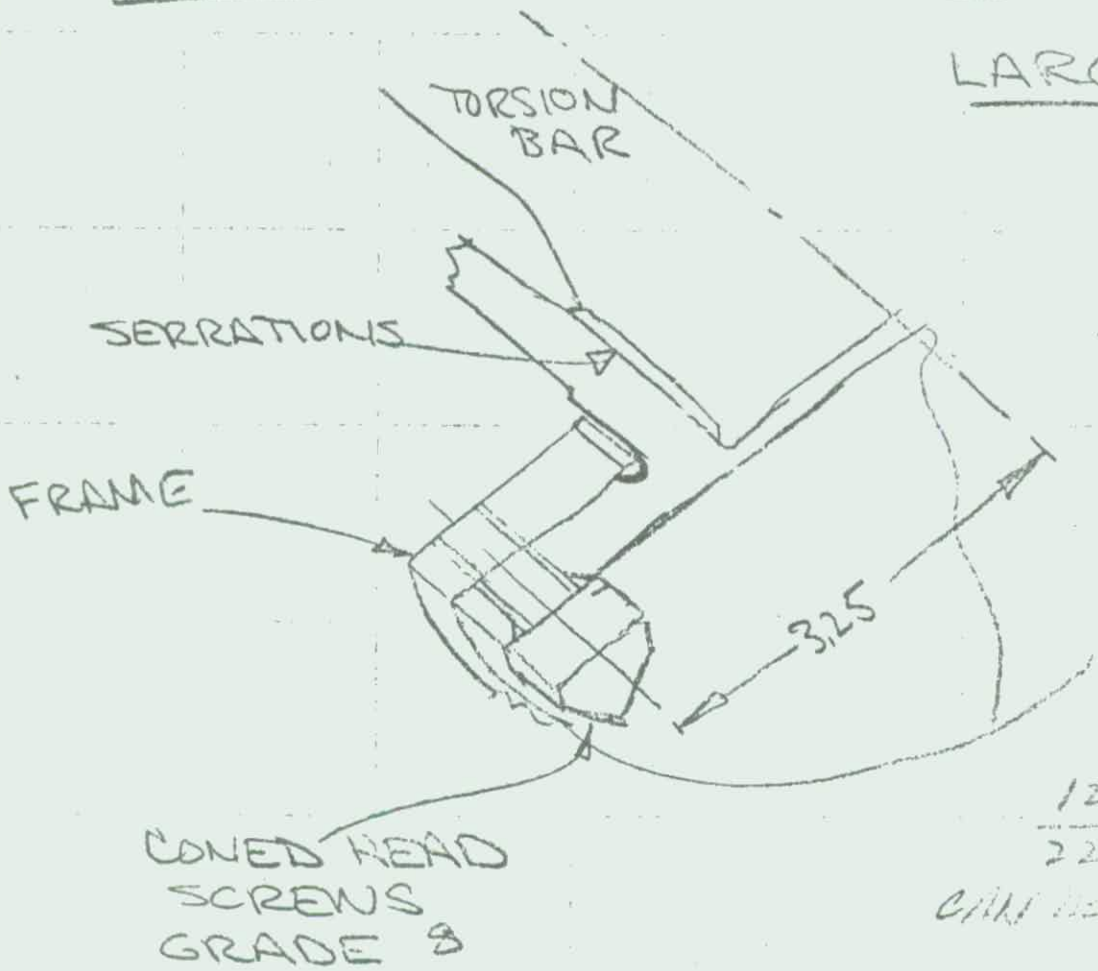
PAGE 1 OF

REPORT NO.

TORSION BAR ANCHOR

LARGE BAR



7/8-14 (5)

CU[illegible] LOAD = 5(45,000) = 225,000#

[illegible]

Head [illegible]

$\frac{125800}{225000} = .55$

[illegible]

MAX TORQUE ON BAR = 409,000 LB-IN

SHEAR FORCE TO BE SUPPLIED BY SCREWS = 409,000/3.25

= 125,800#

FOR GRADE 8 SCREWS, FS=2 ON YIELD

10 SCREWS

AREA REQD = $\frac{125,800/10}{120,000} \times 2$ = .21 IN^2

5/8-18 IS .2560 IN^2

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ORDER NO.
PAGE 1 OF
REPORT NO.

PANHARD ROD - DRIVE AXLE

ROD TRANSFERS SIDE LOADS ON AXLE TO FRAME

DESIGN LOAD = 3 (NOM STATIC WHEEL LOAD W/HOWITZER)
= 3(8250) = 24750#
(CAN BE TENSION OR COMPRESSION)

COLUMN LOADING
LENGTH = 49.18"
FOR A 2 OD x .125 WALL TUBE
$L/r = 49.18/.6644 = 74.2$
FOR TUBULAR COLUMN - NO END RESTRAINT
(ROARK - p.237)

$\frac{Q}{A}$ ALLOWABLE = $\frac{P}{1.5A}$ (S_y = 60,000 psi)
(4130, 8630)
(NORMALLIZED)

$P/A = 60000 - 1.172 \left(\frac{L}{r}\right)^2$

$= 60000 - 1.172(74.2)^2$

$= 60000 - 5490 = 54,510\ \#/\text{IN}^2$

$A\ \text{REQD} = \frac{Q(1.5)}{P/A} = \frac{24750(1.5)}{54,510} = .68\ \text{IN}^2$

A OF TUBE = .736 IN²

OK

IN TENSION (FOR FACTOR OF SAFETY = 2)

$\sigma = P/A = \frac{24750(2)}{.736} = 67,200\ \text{psi}$

HEAT TREAT R_{H_C} 31-36

σ_{yield} = 95-110 KSI FOR 8630
4130 HIGHER

158

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ORDER NO.

PAGE 1 OF

REPORT NO.

PANHARD ROD – STEER AXLE

LENGTH = 23.4

LOAD = 3 X WHEEL LOAD = 3(5100#)
= 15,300#

TRY 1.50 OD x .093 WALL (4130, 8630)
r = .498 l/r = 23.4/.498 = 47

$$\frac{Q}{A} \text{ ALLOWABLE} = \frac{P}{1.5A}$$

$$P/A = S_y - 1.172\left(\frac{l}{r}\right)^2$$

$$= 60{,}000 - 1.172(47)^2 = 60{,}000 - 2590$$

$$= 57{,}410 \text{ psi}$$

$$A_{REQ'D} = \frac{Q(1.5)}{P/A} = \frac{15{,}300(1.5)}{57{,}410} = .400 \text{ IN}^2$$

1.50 x .093 TUBE A = .4142 OK

TENSILE LOAD (FOR FS=2)

$$\sigma = \frac{2P}{A} = \frac{2(15{,}300)}{.414} = 73{,}900 \text{ psi}$$

HEAT TREAT RHC 31-36

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PAGE 1 OF 3

REPORT NO.

STEERING SYSTEM — STEER AXLE

1. Kingpin Torque

$$T = Wf\sqrt{\frac{B^2}{8} + E^2}$$

W = vehicle weight* = 5100 lb

B = Nom. tire width = 12.00 in

E = Kingpin eccentricity = 10.30 in

f = Coeff of friction based on E/B (= .86)

= .12

$$T = (5100)(.12)\sqrt{\frac{(12.00)^2}{8} + (10.30)^2}$$

$$= \underline{\underline{6817.4 \text{ in-lb}}}$$

* on rear axle

2. Required Force

$$F = \frac{T}{r}$$

T = Kingpin Torque = 6817.4 in-lb

r = Effective Radius Arm = 4.60 in

$$F = \frac{6817.4}{4.60} = 1482 \text{ lb}$$

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$P_{max} = 2200$ psi

A req'd $= \frac{F}{P} = \frac{1482}{2{,}200} = .674$ in^2

$A = A$ rod end $+ A$ piston face

$= \pi[R^2 - r^2] + \pi[R^2]$

$= \pi[2R^2 - r^2]$

Try a 1.50 bore with a .75 in rod

$A = \pi[2(.75)^2 - (.375)^2] = 3.09$ in^2

Req'd pressure to create a 1482 lb force

$P = \frac{1482}{3.09} = 479$ psi

Set r at 3.40 inches (a 6.00 radius of action)

$F = \frac{6817.4}{3.40} = 2{,}050$ lb

$A = \frac{2{,}050}{2{,}200} = .913$ in^2

A of cyl is 3.09 in^2 - effective

P used $= \frac{2{,}050}{3.09} = 650$ psi

PCF-RN-597

The selected cylinder is a 1.50 ID X 6.00 stroke, 2 used per axle

$$A = \frac{\pi}{4}(D)^2 = \frac{\pi}{4}(1.50) = 1.767 \text{ in}^2$$

$$V = AS = (1.767)(6.00) = 10.60 \text{ in}^3$$

Steering wheel turns

$$\text{Orbitrol Displacement} = \frac{2V}{N}$$

Set N at 4.0 turns, lock to lock

$$\text{Orbitrol Displacement} = \frac{2(10.60)}{4} = 21.20 \frac{\text{in}^3}{\text{rev.}}$$

The cylinder selected for the rotary actuator (Loaded condition) is the YU-12 that has a displacement of 47.16 in³/rev.

$$N = \frac{21.2 \text{ in}^3}{47.16 \text{ in}^3/\text{rev.}} = .45$$

As this is much quicker and needs less power than the rotary actuator, the loaded condition must take precedence in sizing calculations.

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DATE 12/6/73 | REPORT NO.

STEER AXLE - TIE ROD

TIE ROD MAX LOAD WILL OCCUR WHEN AXLE IS TIPPED AND ALL AXLE LOAD IS ON ONE WHEEL

THEN ONE CYLINDER WILL BE TRANSMITTING ITS FORCE THROUGH THE TIE ROD TO THE OTHER WHEEL

WORST CASE WILL BE IF THE CYLINDER FORCE RESULTS FROM THE PISTON AREA SO THE TIE ROD FORCE WILL BE

$$F_T = \frac{M_T(@5100^{\#}\text{ AXLE LOAD})}{2R_{MIN}} \frac{A_P}{A_R}$$

M_T = TURNING MOMENT

R_{MIN} = MIN TIE ROD MOMENT ARM

A_P = AREA-PISTON END OF CYL

A_R = AREA-ROD END OF CYL

$$F_T = \frac{1620}{2(3.40)} \times \frac{.913}{.605} = \underline{\underline{360^{\#}}}$$

PUSH OR PULL

FOR COLUMN LOADING

Q/A ALLOWABLE $= \frac{P/A}{1.5}$ FOR TUBULAR, PIN END COLUMN

FOR $S_y = 36{,}000$ psi

$$\frac{P}{A} = 36000 - 1.172\left(\frac{L}{r}\right)^2 \quad \text{(ROARK-p237)}$$

$L = 52.88$ IN

$r = .3217$, FOR 1 OD x .095 WALL

$$\frac{P}{A} = 36000 - 1.172\left(\frac{52.88}{.3217}\right)^2 = 4300\ psi$$

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY WK

CHECKED BY

DATE 12/6/73

ORDER NO.

PAGE 2 OF

REPORT NO.

$$\text{MIN A REQD} = \frac{1.5Q}{P/A} \qquad Q = 350^{\#}$$

$$= \frac{1.5(350)}{4300} = .122 \text{ IN}^2$$

FOR 1.00 OD x .095 WALL TUBE, $A = .2701 \text{ IN}^2$

OK

PCF-RN-597

Gabriel
22371 Newman Avenue, Dearborn, Michigan — 48124
Phone: Area 313 — LO. 1-7937 TWX—313-278-9756

December 21, 1973

Mr. H. G. Kirchner
PACIFIC CAR & FOUNDRY
1400 4th St. North
Renton, Washington 98055

Dear Mr. Kirchner:

Supplementing our letter of December 4th we are attaching the following:

I. Rear Shock Data - 1-5/8" Bore

A. Typical unit outline drawing 680055 which indicates recommended 2.5 dia. mounting ends and method of dimensioning.

B. Section Drawing 422512 illustrating unit construction and minimum dead length of 4.00 plus mounting ends. Strokes can be specified in .250 increments.

C. Installation drawing 420212 which shows Type I mounting we recommend for rear.

II. Front Shock Data - 1-3/8" Bore

A. Typical unit outline drawing 651018 illustrating integral mounting which uses .75 dia. bolt.

B. Section Drawing 422517 describing unit and minimum dead length 3.952 plus mounting ends. Strokes available in .25 increments.

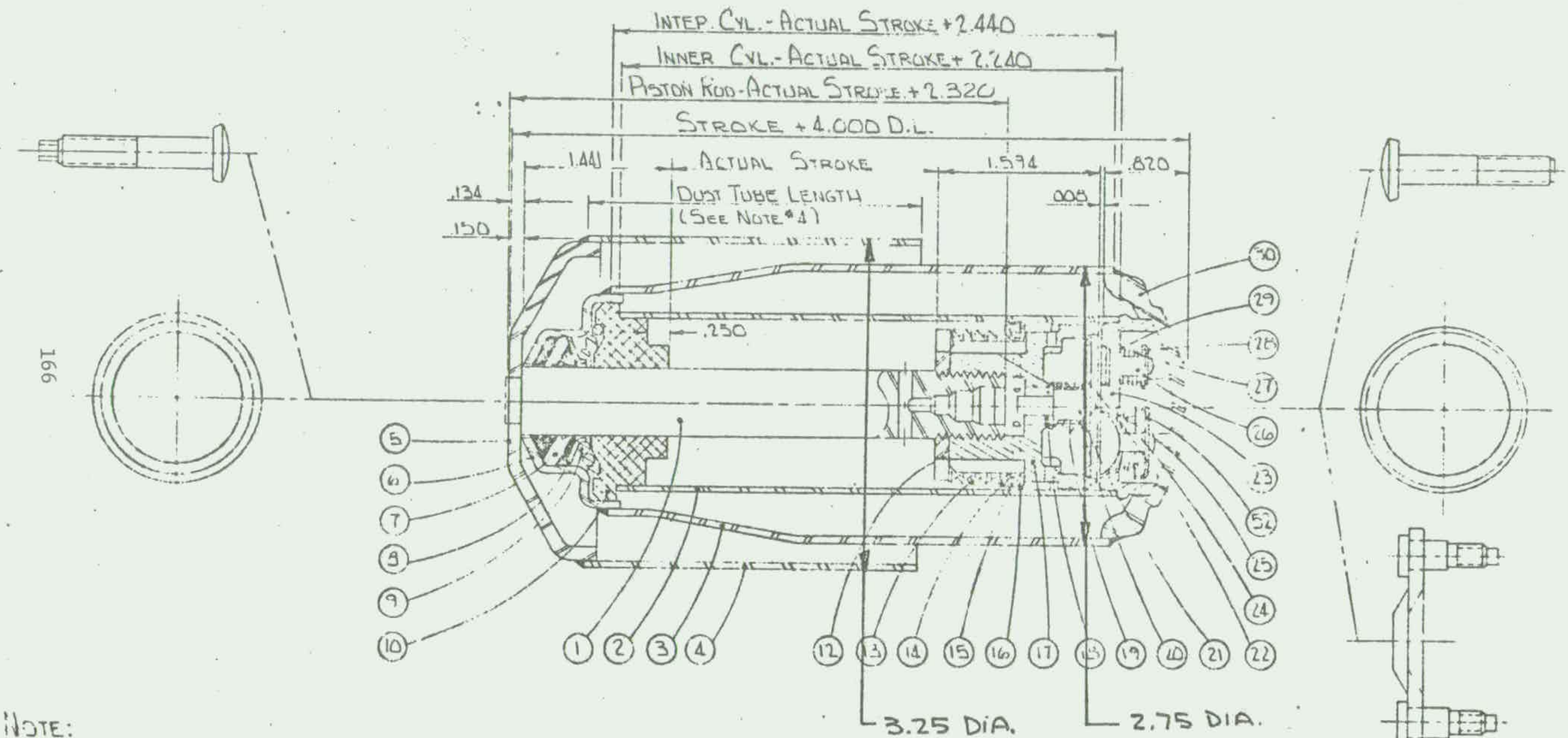
We trust this information will be of aid to you.

Very truly yours,

GABRIEL OF CANADA

Ral F. Homovec
General Sales Manager

RFH:md



NOTE:

1. ✳ SYMBOL DENOTES AFTER WELDING DIMENSIONS.
2. USE ACTUAL STROKE FOR CALCULATIONS. ACTUAL STROKE IS .010 LONGER THAN NOMINAL STROKE. EXAMPLE: 5.00 NOM. STROKE IS 5.01 ACTUAL STROKE.
3. FLUID QUANTITY (IN CC) 61 TIMES NOMINAL STROKE + 110 c.c.
4. DUST TUBE LENGTH 1.650 LESS THAN PISTON ROD LENGTH.

TOL. DECIMAL ± . ANGULAR ± WT.

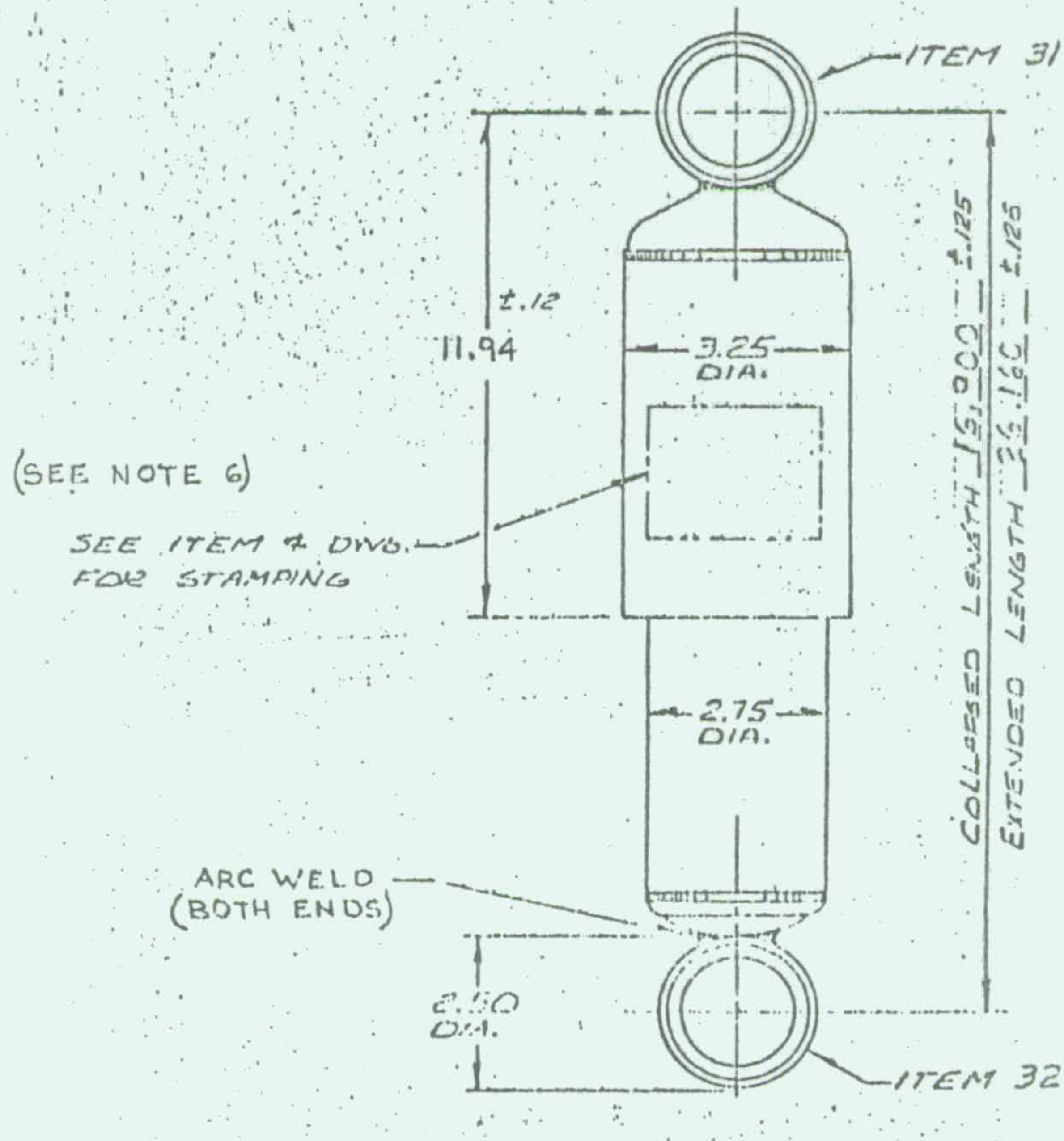
DATE	LET	ALTERATIONS	D.C. No	SCALE: 1 To 1	MAT'L
				DRAWN: J. McCAUGHERTY	
				DATE: JAN 1963	NAME: SHOCK ABSORBER SECTION DRAWING 1 3/8 HEAVY DUTY PERMANENT CHARGE
				CHECKED: AJN	
				APPROVED	No. 422512
D.R. No. 5571		SUPERSEDES -		GABRIEL OF CANADA LTD. TORONTO, ONTARIO	

(SPEC. 420163)

NOTE:-

1. VALVE CODE F8(
2. STROKE 9.26 D.L. 7.64
3. SECTION DWG. 422512 (RECOIL CUT-OFF)
4. ASSEMBLY SPEC. 438020
5. 2 PLACE DIMS. (XX) ARE REF.
6. ITEMS 2, 3 & 70 USE 10.51 STROKE

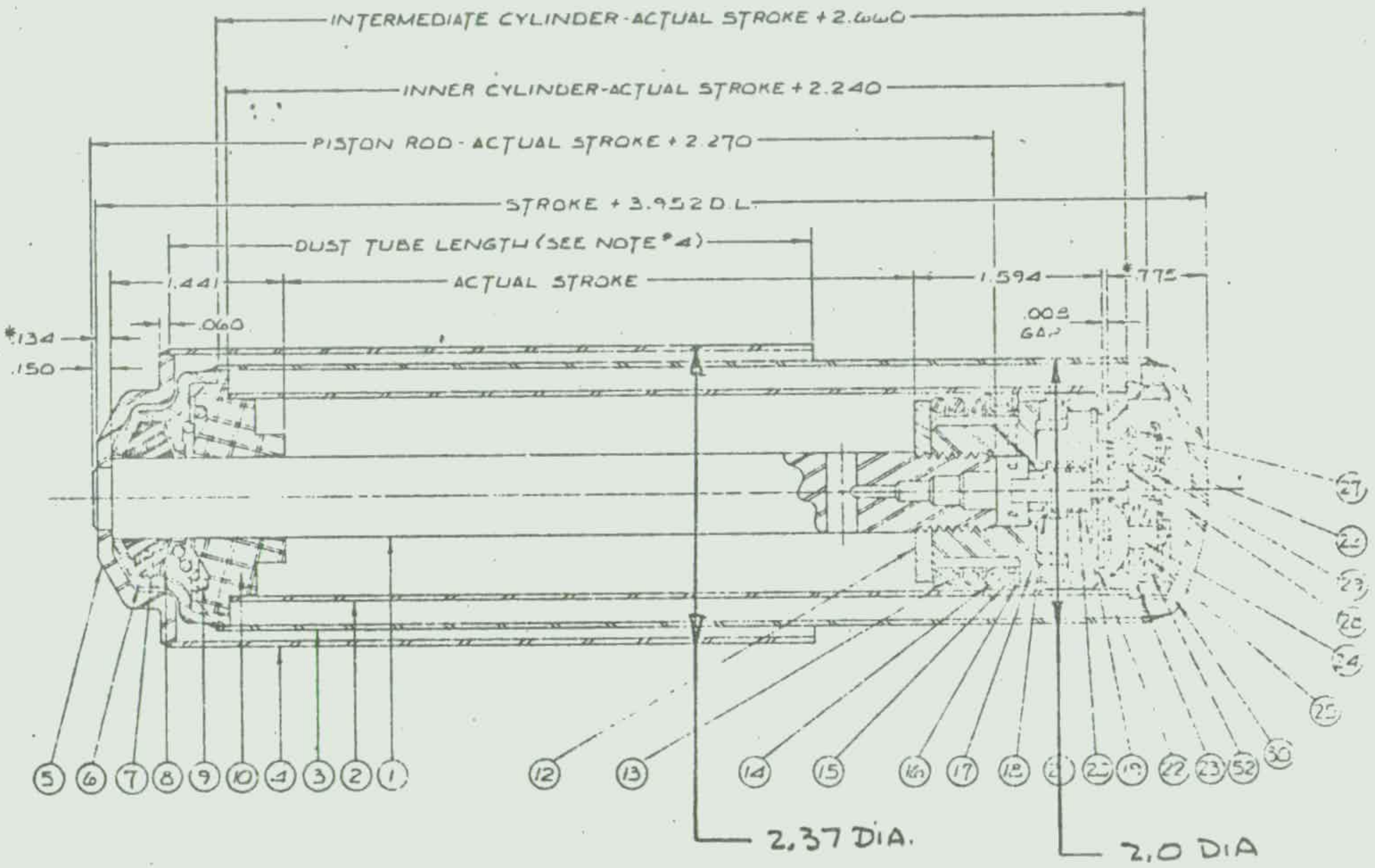
	QTY. REQU
	1
	751
	A.R



SHOCK ABSORBER (1.625 BORE) HEAVY DUTY

TX 68005

168



NOTES:

1. * SYMBOL DENOTES AFTER WELDING DIMENSIONS.
2. USE ACTUAL STROKE FOR CALCULATIONS - ACTUAL STROKE IS .010 LONGER THAN NOMINAL STROKE
   Example 5.00 NOMINAL STROKE IS 5.01 ACTUAL STROKE
3. FLUID QUANTITY (INC.C.) 40 x NOMINAL STROKE + 7[illegible] C.C
4. DUST TUBE LENGTH IS 1.650 LESS THAN PISTON ROD LENGTH.

TOL DECIMAL ± ANGULAR ± WT.

SCALE	MAT'L
DRAWN	
DATE	NAME
CHECKED	
APPROVED	No.

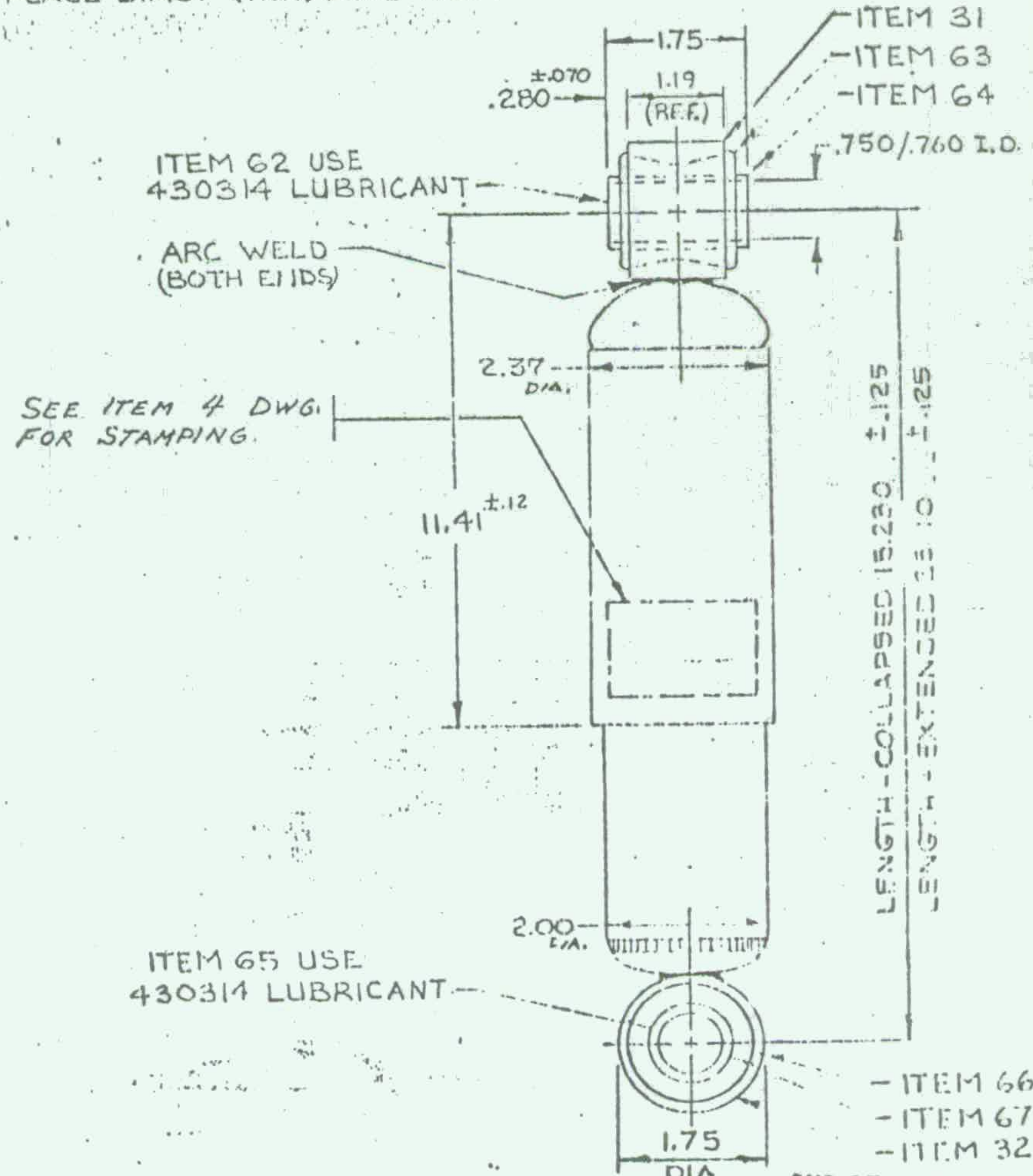
DATE	LET.	ALTERATIONS	D.C. No.

D.R. No. 5[illegible] SUPERSEDES

GABRIEL OF CANADA LTD.
TORONTO ONTARIO

NOTE

1 VALVE CODE: 74(
2 STROKE: 9.88 D.L.: 5.35
3 SECTION DWG.: 4?2??? (RECOIL CUT-OFF)
4 ASSEMBLY SPEC.: 438020
5 NOM. OVERALL COLL. LENGTH:
6 2 PLACE DIMS. (.XX) ARE REF.

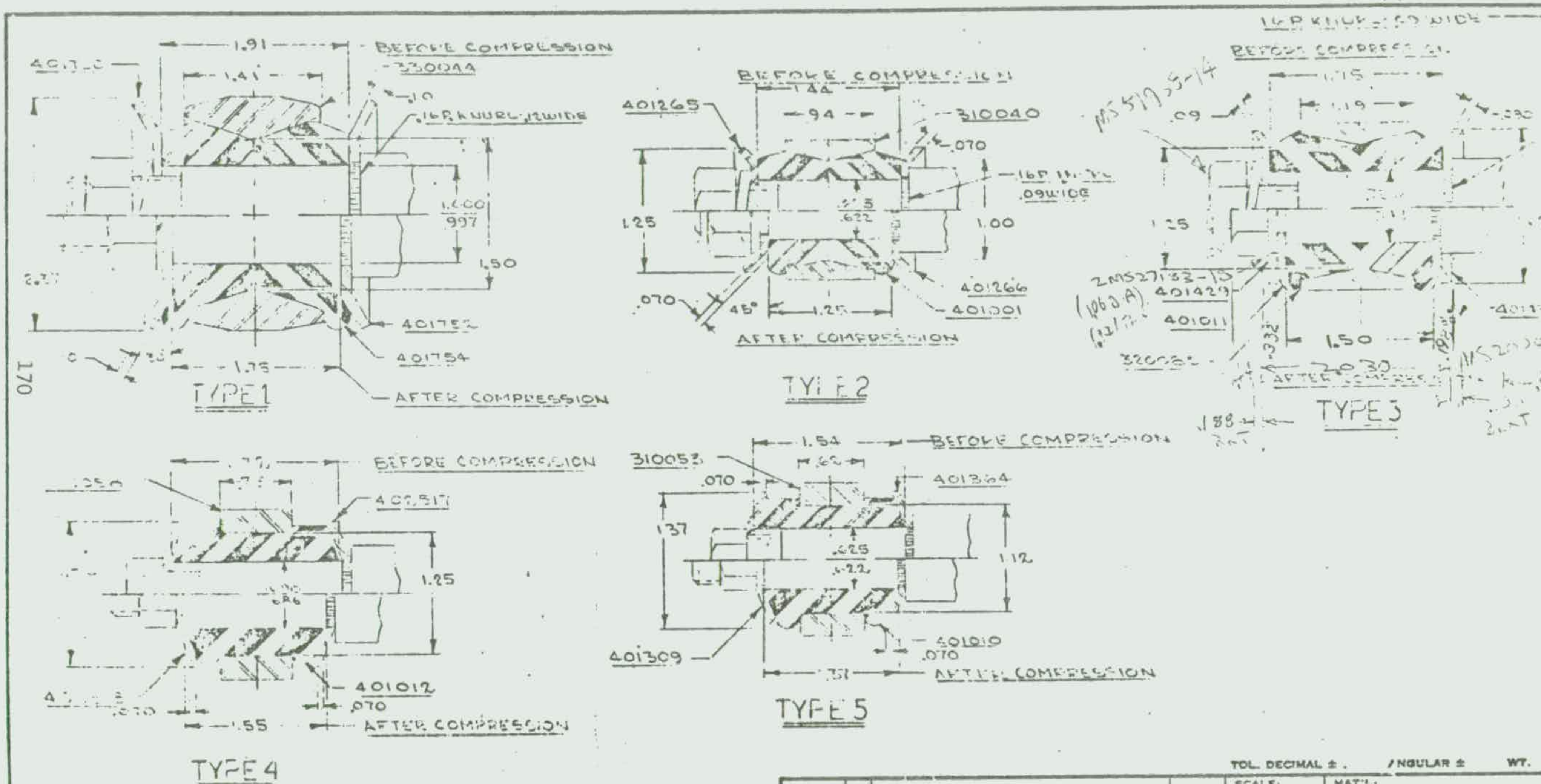


AUG 27 1973

SHOCK ABSORBER
(1.375 BORE)

TX 651018

170



NOTE:

INDIVIDUAL DETAIL DWG. FOR OTHER DIMENSIONS AND TOLERANCE

TOL. DECIMAL ± . ANGULAR ± WT.

SCALE: FULL

DRAWN:

DATE:

CHECKED:

APPROVED:

MAT'L:

NAME: CHART OF ... BUSHING ASSEM...

No. 425212

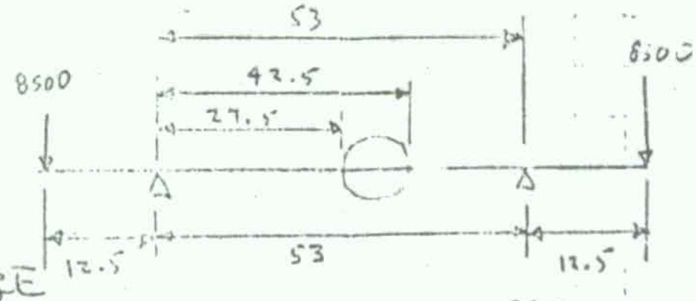
DATE | LET. | ALTERATIONS | D.C. No.

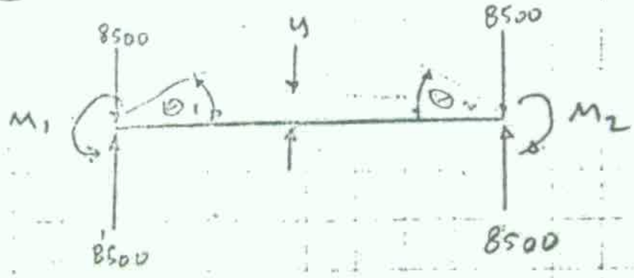
D. R. No. | SUPERSEDES -

THE GABRIEL COMPANY
CLEVELAND OHIO

Atlas axle housing 1/24/79

1. STATIC LOADING ASSUMING ~~LOAD PERP.~~ SQUARE TO AXLE SECTION





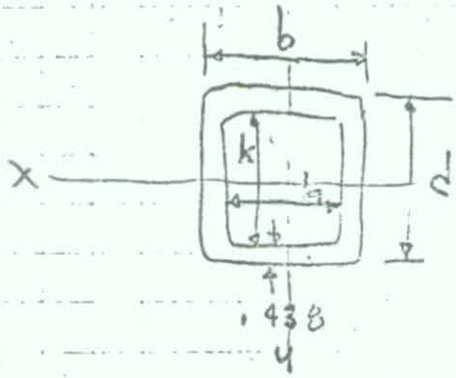
9950 VERT
5300 HOR

$M_1 = M_2 = 8500 \times 12.5 = 106,250$

$M_x = M_1 = M_2 = 106,250$

$I = 14.99$, $Z = 7.05$

x	M	y′	$y = y'/I$	$\sigma_1 = M/Z$
27.5	106,250	1.28	.085	15,071
42.5	106,250	.82	.055	15,071



b = 3.813
d = 4.25
h = 3.813 − 2 × .438 = 2.937
k = 4.25 − 2 × .438 = 3.374

$$I_{x-x} = \frac{bd^3 - hk^3}{12} = \frac{3.813 \times 4.25^3 - 2.937 \times 3.374^3}{12} = 14.99$$

$$Z_{x-x} = \frac{2 I_{x-x}}{d} = \frac{2 \times 14.99}{4.25} = 7.05$$

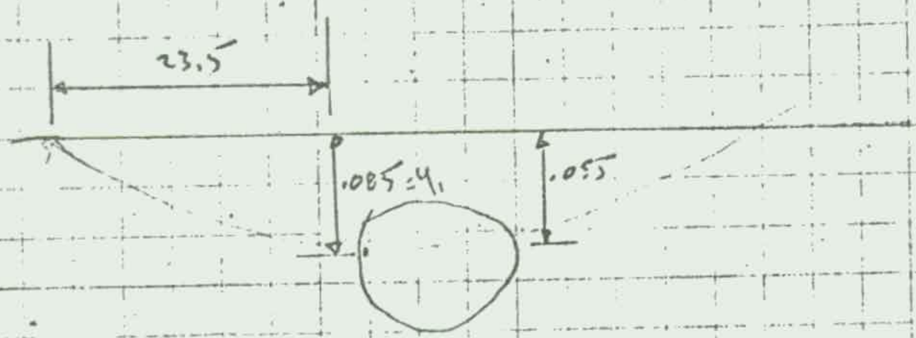
$$I_{y-y} = \frac{db^3 - kh^3}{12} = \frac{4.25 \times 3.813^3 - 3.374 \times 2.937^3}{12} = 12.51$$

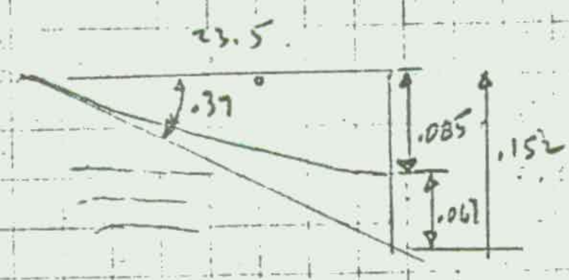
$$Z_{y-y} = \frac{2 I_{y-y}}{b} = \frac{2 \times 12.51}{3.813} = 6.56$$

$$\theta_1 = \theta_2 = \frac{ML}{EI}\left(\frac{1}{3}+\frac{1}{6}\right) = \frac{ML}{EI}\,\frac{1}{2} = \frac{ML}{2EI}$$

$M = 106{,}250$, $I = 14.99$

$$\theta_1 = \frac{106{,}250 \times 53}{2 \times 29{,}000{,}000 \times 14.99} = .0065 \text{ rad} = .37^\circ$$





$y_{diff} = y_1 - y_2 = .152 - .085 = .067$

THIS IS THE DEFLECTION THAT THE AXLE SHAFT WILL UNDERGO BECAUSE OF THE MOMENT AT THE SPLINED END OF THE AXLE SHAFT.

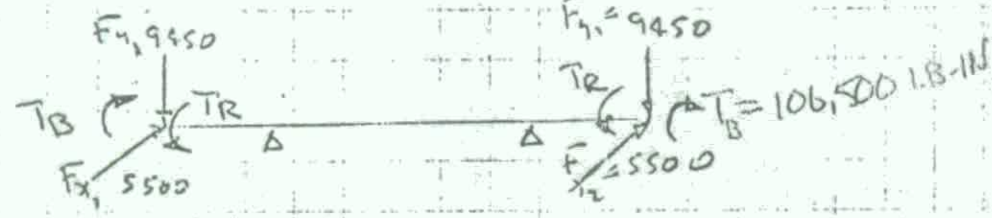
Combined loading due to braking

BRAKING TORQUE IS REACTED AT SUSP. ARMS

NO TORSIONAL STRESS IN CENTRAL ~~INNER~~ PART OF HUB

At wheel: $F_y = 9450$

$F_x = 5500$



$M_{x_1} = M_{x_2} = 12.5 \times 9450 = 118,125$

$M_{y_1} = M_{y_2} = 12.5 \times 5500 = 68,750$

$\sigma_x = \dfrac{M_{x_1}}{Z_{x-x}} = \dfrac{118,125}{7.05} = 16,755$

$\sigma_y = \dfrac{M_{y_1}}{Z_{y-y}} = \dfrac{68,750}{6.56} = 10,480$

$\sigma_{max} = \sigma_x + \sigma_y = 16,755 + 10,480 = 27,235$ (AT CORNER)

SHEAR STRESS WILL BE MAX AT MID POINT OF LONG SIDE OF RECTANGLE

LONG SIDE:

$\tau = \dfrac{T}{2t(b-t)(d-t)}$

$= \dfrac{106,500}{2(.44)(4.25-.44)(3.81-.44)}$

$= \underline{9420 \text{ PSI}}$

SHORT SIDE:

~~T~~ ~~2t(...)~~

STRESS IS SAME BECAUSE THICKNESS IS CONSTANT

$y_1 = \dfrac{1.28}{106,250} \dfrac{M_{x_1}}{I_{x-x}} = \dfrac{1.28 \times 118,125}{106,250 \times 14.99} = .095$

$x_1 = \dfrac{1.28}{106,250} \dfrac{M_{y_1}}{I_{y-y}} = \dfrac{1.28 \times 68,750}{106,250 \times 12.51} = .066$

$d_1 = \sqrt{y_1^2 + x_1^2} = \sqrt{.095^2 + .066^2} = .116$

$$\theta_{z_1} = \frac{M_{x_1} L}{2E I_{x-x}} = \frac{118{,}125 \times 53}{2 \times 29{,}000{,}000 \times 14.99} = .0072 \text{ rad} = .413^\circ$$

$$\theta_{x_1} = \frac{M_{y_1} L}{2E I_{y-y}} = \frac{68{,}750 \times 53}{2 \times 29{,}000{,}000 \times 12.51} = .0050 \text{ rad} = .288^\circ$$

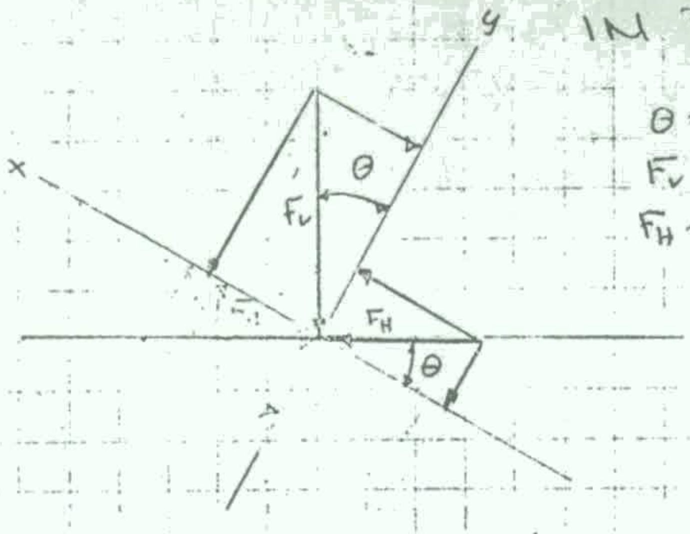
$$y_1 = 23.5 \tan \theta_{z_1} = 23.5 \times \tan .413^\circ = .169$$

$$x_1 = 23.5 \tan \theta_{x_1} = 23.5 \times \tan .288^\circ = .118$$

$$d_s = \sqrt{y_1^2 + x_1^2} = \sqrt{.169^2 + .118^2} = .206$$

$d_{net} = d_s - d_y = .206 - .116 = .090$ (NET ~~A~~XLE SHAFT DEFLECTION FROM PANIC STOP

WITH AXLE TIPPED 23.5° & LOADED IN PANIC STOP



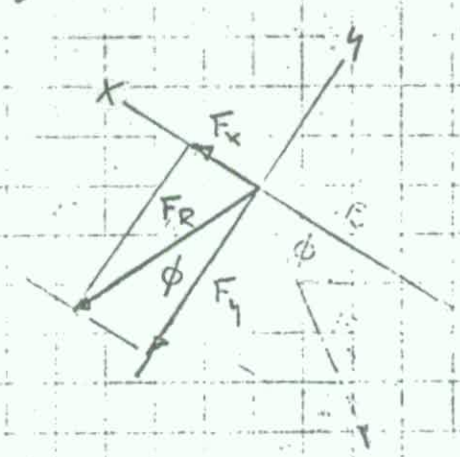
$\theta = 23.5^\circ$

$F_v = 9450$

$F_H = 5500$

$F_y = F_v \cos\theta + F_H \sin\theta = 9450 \cos 23.5^\circ + 5500 \sin 23.5^\circ = 10{,}859$

$F_x = F_v \sin\theta - F_H \cos\theta = 9450 \sin 23.5^\circ - 5500 \cos 23.5^\circ = -1276$



$F_R = \sqrt{F_x^2 + F_y^2} = \sqrt{-1276^2 + 10{,}859^2} = 10{,}934$

$\phi = \tan^{-1}\left(\frac{-F_x}{F_y}\right) = \tan^{-1}\left(\frac{1276}{10{,}859}\right) = 6.7^\circ$

Check

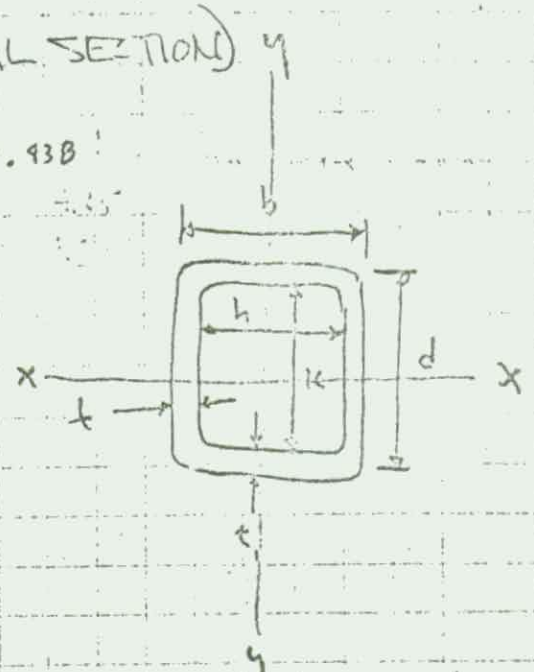
$F_R = \sqrt{F_v^2 + F_H^2} = \sqrt{9450^2 + 5500^2} = 10{,}934$

$M_x = 12.5 \times F_y = 12.5 \times 10{,}859 = 135{,}738$

$M_y = 12.5 \times F_x = 12.5 \times 1276 = 15{,}950$

Design ① (ORIGINAL SECTION)

$K = 3.374$, $h = 2.937$, $b = 3.813$, $d = 4.25$, $t_1 = .438$



$$I_{x-x} = \frac{3.813 \times 4.25^3 - 2.937 \times 3.374^3}{12} = 14.99$$

$$Z_{x-x} = \frac{2 \times 14.99}{4.25} = 7.05$$

$$\sigma_x = \frac{135,738}{7.05} = 19,254$$

$$I_{y-y} = \frac{4.25 \times 3.813^3 - 3.374 \times 2.937^3}{12} = 12.51$$

$$Z_{y-y} = \frac{2 \times 12.51}{3.813} = 6.56$$

$$\sigma_y = \frac{15,950}{6.56} = 2431$$

$$\sigma_{max} = 19,254 + 2431 = 21,685$$

~~(AT CORNER)~~

COMBINED STRESS W/TORQUE ADDED

@ Y-Y AXIS $\sigma = 19,254$ PSI
$\tau = 9420$ psi

$$\sigma_{COMB} = \sigma/2 + \sqrt{\frac{\sigma^2}{4} + \tau^2}$$

$$= 19,254 + \sqrt{\frac{19,254^2}{4} + 9420^2}$$

$$= \underline{32,724} \text{ PSI}$$

~~(SHEAR STRESS SAME AS BEFORE)~~

Design ② (ADDING .25 THICK PLATES TOP & BOTTOM

$K = 3.374$, $h = 2.937$, $b = 3.813$, $d = 4.25 + .50 = 4.75$, $t_1 = .438 + .25 = .688$

$$I_{x-x} = \frac{3.813 \times 4.75^3 - 2.937 \times 3.374^3}{12} = 24.65$$

$$Z_{x-x} = \frac{2 \times 24.65}{4.75} = 10.38$$

$$\sigma_x = \frac{135,738}{10.38} = 13,077$$

$$I_{y-y} = \frac{4.75 \times 3.813^3 - 3.374 \times 2.937^3}{12} = 14.82$$

$$Z_{y-y} = \frac{2 \times 14.82}{3.813} = 7.77$$

$$\sigma_y = \frac{15,950}{7.77} = 2053$$

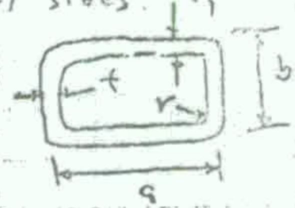
$$\sigma_{max} = 13,077 + 2053 = 15,130$$

Compute shear & combined stress with torsion load added.

$a = 4.75$
$b = 3.813$
$t = .438 + .25 = .688$
$t_1 = .438$

Torsion induced by braking $T = 106{,}500$ in-lb.
Use formula given in ref (1), Table IV, case 11

Average $s_1 = \dfrac{T}{2t(a-t)(b-t_1)}$ near mid-length of short sides



$$s_1 = \frac{106{,}500}{2 \times .688(4.75 - .688)(3.813 - .438)}$$

$s_1 = 5646$ psi

Average $s_2 = \dfrac{T}{2t_1(a-t)(b-t_1)}$ near mid-length of long sides

$$s_2 = \frac{106{,}500}{2 \times .438(4.75 - .688)(3.813 - .438)}$$

$s_2 = 8869$ psi

Combined stress at middle of each side

Middle of short side (b)

Bending stress $= \sigma_x = 13{,}077$
Shear stress $= s_1 = 5646$

Combined stress $= \sigma_{comb} = \dfrac{\sigma}{2} + \sqrt{\dfrac{\sigma^2}{4} + s_1^2}$

$$\sigma_{comb} = \frac{13{,}077}{2} + \sqrt{\frac{13{,}077^2}{4} + 5646^2} = 15{,}177$$

Middle of long side

Bending stress $= \sigma_y = 2053$
Shear stress $= s_2 = 8869$

$\sigma \approx 2053 \quad \sqrt{2053^2 \quad 8869^2} = 9155$

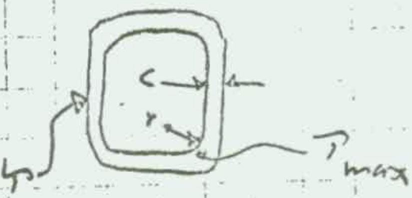
Combined stress at corner considering stress concentration under torsional loading. Stress concentration factor is theoretical maximum which may never be attained under actual loading conditions using ductile material.

K_{t_s} - stress concentration factor

τ - shear stress

$$\tau_{max} = \tau K_{t_s}$$

$$K_{t_s} = f(r/c)$$



Assume $c = \frac{t + t_1}{2} = \frac{.688 + .438}{2} = .563$

$r = 3/16 = .1875$

$r/c = .1875/.563 = .333$

From Fig. 113, ref (2)

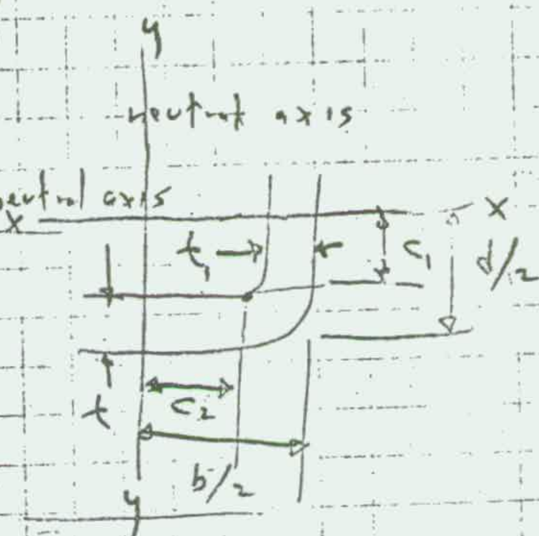
$K_{t_s} = 2.1$

Use $\tau = \frac{S_1 + S_2}{2} = \frac{5646 + 8869}{2} = 7258$

$$\tau_{max} = 7258 \times 2.1 = 15,242$$

Bending stress at inside corner

Since z_{x-x} and z_{y-y} are base on the distance from the neutral axis to the outermost fiber a reduced bending stress is computed using c_1' and c_2'.



$$\sigma_x' = \frac{c_1}{d/2}\sigma_x = \frac{1.687}{2.375} 13,077 = 9289$$

$$\sigma_y' = \frac{c_2}{b/2}\sigma_y = \frac{1.47}{1.91} 2053 = 1580$$

$c_1 = d/2 - t_1 = 2.375 - .688 = 1.68$

$d/2 = 4.75/2 = 2.375$

$c_2 = b/2 - t = 1.91 - .4383 = 1.4$

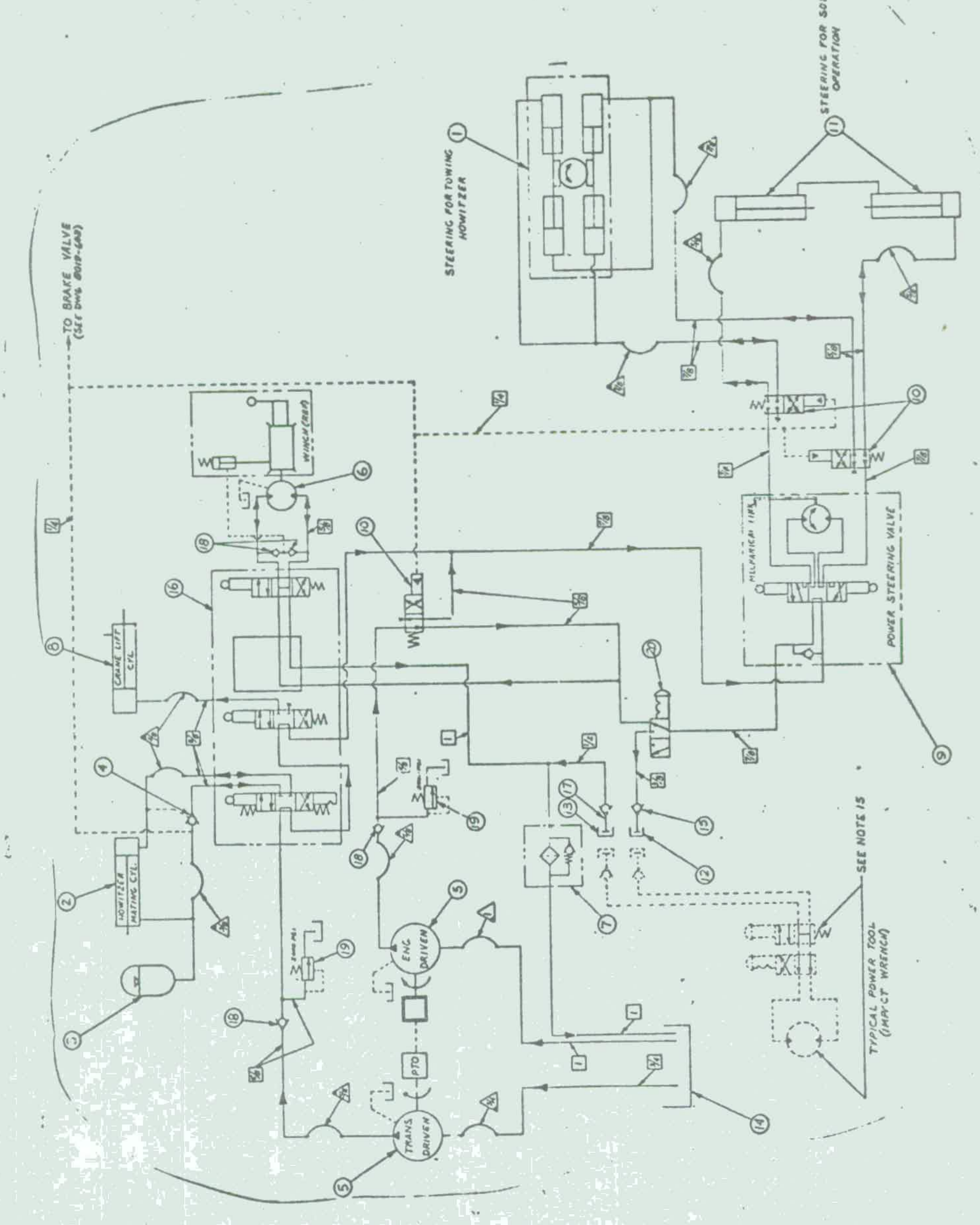
$b/2 = 3.813/2 = 1.91$

Combined stress

$$\sigma_c = \frac{1}{2}(\sigma_x' + \sigma_y') + \sqrt{\frac{(\sigma_x - \sigma_y)^2}{4} + \tau_{max}^2} = \frac{1}{2}(9289 + 1580) + \sqrt{\frac{(9289 - 1580)^2}{4} + 15{,}2}$$

$$\sigma_c = 21,156$$

... Design Factors — Peterson



STEERING FOR TOWING HOWITZER
POWER STEERING VALVE
WINCH
CRANE LIFT CYL.
HOWITZER MATING CYL.
ENG DRIVEN
TRANS DRIVEN
PTO
SEE NOTE 15
TYPICAL POWER TOOL (IMPACT WRENCH)

PRESS = ~~[illegible]~~ PSI

BOOM CYL.

LOAD = 2000 lb.

$$\overset{\text{LOAD}}{2000} \times \overset{\text{ARM.}}{22.6} = \overset{\text{ARM}}{5.4} \times F$$

$$F = \frac{2000 \times 22.6}{5.4}$$

$$= 8360$$

$$\pi$$

$$A_{RH} = \frac{8360}{1800} = 4.65\ IN^2$$

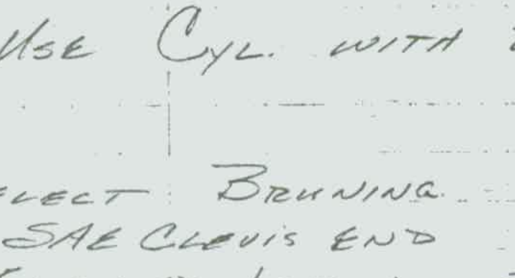
$$\sqrt{\frac{4.65}{3.14}} = r$$

$$1.215 = r$$

$$d = 2.43$$

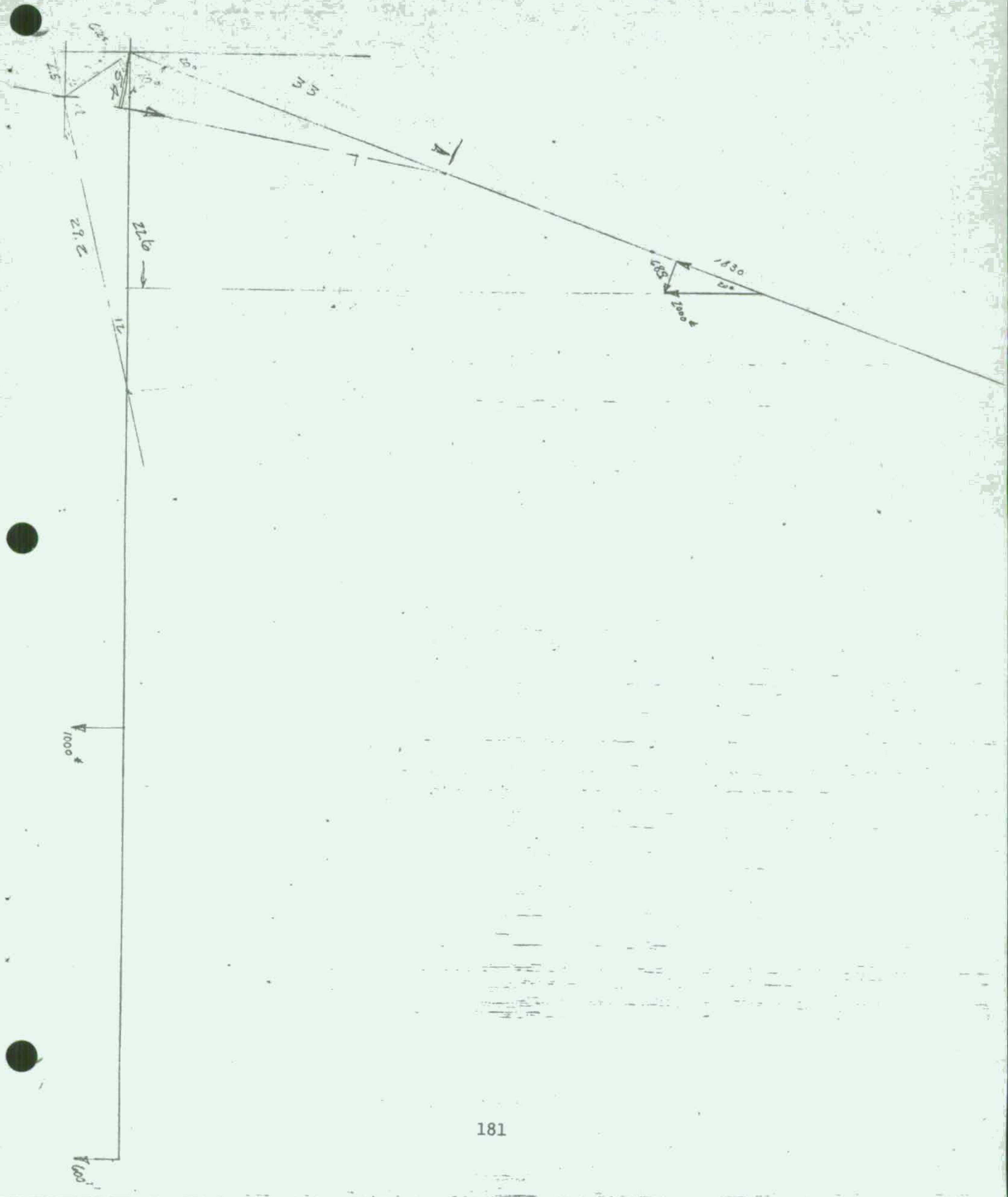
USE CYL. WITH 2 1/2 IN BORE

SELECT BRUNING 3-2.5-20.25-RE1
SAE CLEVIS END
EXTENDED LENGTH 37.75
RETRACTED LENGTH 29.13



$$\begin{array}{r} 2.00 \\ 4.50 \\ .75 \\ \underline{1.63} \\ 8.88 \end{array}$$

29.13 − 8.88 = STROKE
20.25 = STROKE


1830

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY J. CRAIG

ORDER NO. ATLAS

CHECKED BY

PAGE ____ OF ____

DATE 11-16-73

REPORT NO.

RESERVOIR — OPEN CIRCUIT

20 GAL x 231 IN³/GAL = 4,620 IN³

INSIDE WIDTH - 7.75"
" LENGTH - 24.50"
" HEIGHT - 22.75

$$\frac{24.50 \times 22.75 \times 7.75}{231} = 18.7 \text{ GAL}$$

LESS VOLUME TO HIGH MARK.

$$\frac{18 \times 7.75 \times 3}{2 \times 231} = .9 \text{ GAL}$$

18.7 - .9 = 16.8 GAL

WT = 16.8 GAL x 7.5 #/GAL = 126 #

SEE LAYOUT 8019-503 FOR DETAILS
8019-502 FOR LOCATION

PCF-PN-597

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY J. CRAIG | ORDER NO. ATLAS
CHECKED BY | PAGE 1 OF 2
DATE 11-16-73 | REPORT NO.

PROBLEM — CAN ATLAS USE MANUAL STEER ON SANDY DIRT SOIL IN LOADED CONDITION

ASSUME — ROLLING RESISTANCE — 37#/1000# ON SANDY DIRT SOIL

AXLE LOAD IN LOADED — 17,670# CONDITION

TRACK WIDTH — 78"

TORQUE REQUIRED TO TURN DRIVE AXLE IN SANDY DIRT

$$T = \frac{17{,}670}{1000} \times 37 \times \frac{78}{2} = 25{,}400 \text{ in-lb.}$$

ROTARY ACTUATOR — HYDRA POWER P/N TR180-15011- PRODUCES 150,000 IN-lb. AT 3000 PSI

$$\frac{150{,}000}{3000} = 50 \text{ in-lb/psi}$$

PRESSURE REQUIRED BY MANUAL OPERATION OF ORBITROL PUMP

$$\frac{25{,}400}{50} = 510 \text{ psi}$$

PCF-RN-597

ORBITROL DISPLACEMENT SELECTION
ROTARY ACTUATOR

ASSUME t = 4 SECS
N = 4 TURNS

CYL VOL = 184 IN³

ORBITROL DISP = $\frac{\text{CYL VOL}}{N}$ = $\frac{184}{4}$ = 46 IN³/REV

SELECT YU-12 DISP = 47.6 IN³/REV

ACTUAL N = $\frac{184}{47.6}$ = 3.86 TURNS

STEERING WHEEL SPEED $\frac{3.86}{4}$ = .965 REV/SEC

GPM = ORBITROL DISP × WHEEL SPEED × $\frac{60}{231}$

= $47.6 \times .965 \times \frac{60}{231}$ = 11.97

COMBINED PUMP OUTPUT @ 1600 ENG. = 13.0 G

STEER TIME = $\frac{60 \times \text{CYL DISP}}{231 \times \text{GPM}}$

= $\frac{60 \times 184}{231 \times 13.0}$ = 3.68 SECS FULL STEER

STROKE 4.62

LIN. ACTUATOR. 1.5 DIA PISTON - .75 DIA ROD

USING PTO PUMP ONLY - 5.75 GPM @ 1600 ENG.

DISP = 9.86 IN^3

STROKE - 4.62

2 CYL WITH 1.77 IN^2 HEAD END & .378 IN^2 ROD = 2.148 IN^2

CYL. SPEED $= \frac{4.62}{4} = 1.15$ IN/SEC.

STEERING TIME $= \frac{60 \times V}{GPM \times 231} = \frac{60 \times 9.86}{5.75 \times 231} = .445$ SECS.

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY J. CRAIG | ORDER NO. ATLAS

CHECKED BY | PAGE ___ OF ___

DATE 11-13-73 | REPORT NO. ___

WINCH P-10

LINE SPEED (HIGH) BARE DRUM - 127 FPM
FULL DRUM - 236 FPM

(LOW) BARE DRUM - 24 FPM
FULL DRUM - 44 FPM

GEAR RATIO (LOW) 140 : 1
(HIGH) 26 : 1

DRUM DIA = 6½" ROPE DIA = ½"

$$\text{LINE SPEED (FPM)} = \frac{(.5236)(\text{MOTOR RPM})(\text{R TO CENTER WIRE})}{\text{GEAR RATIO}}$$

$$\text{MOTOR RPM} = \frac{\text{LINE SPEED} \times \text{GEAR RATIO}}{(.5236)(\text{RAD TO CENTER WIRE})}$$

$$= \frac{127 \times 26}{.5236 \times 3.5}$$

$$= 1800 \text{ RPM}$$

USING MOTOR ON DRAWING 13218E4112
DISP OF MOTOR = 1.2 IN³/REV

$$Q_{\text{INPUT GPM}} = \frac{1800 \times 1.2}{231} = \underline{9.35 \text{ GPM}}$$

PUMP REQUIREMENT @ η_v = 90%

$$\frac{9.35}{.90} = 10.4 \text{ GPM.}$$

PCF RN-597

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY J. CRAIG

CHECKED BY

DATE 11-16-73

ORDER NO. ATLAS.

REPORT NO.

ASSUME 1 REV/SEC OF STEERING WHEEL OR 60 RPM

FROM ORBITROL DATA

$$\text{DISP} = 23.8 \text{ IN}^3$$
$$T = 2{,}950 \text{ IN-lb.}$$
$$\text{RPM} = 60$$

THEREFORE TORQUE @ 45.7 DISP AND 60 RPM

$$T = \frac{45.7 \times 510}{2\pi} = 3{,}700 \text{ IN-lb.}$$

STEERING WHEEL DIA IS 12"

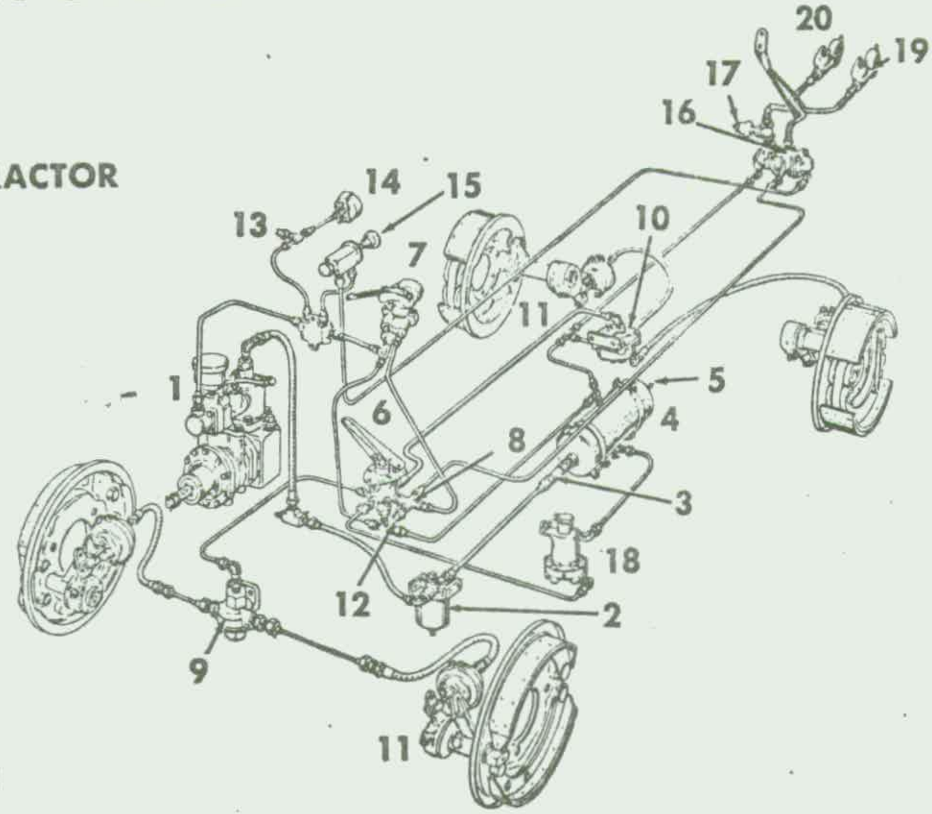
WHEEL INPUT REQUIRED TO DEVELOP 3,700 IN-lb.

$$\frac{3{,}700}{6} = 617^{\#}$$

617# INPUT TO STEERING WHEEL CAN NOT BE ACCOMPLISHED BY DRIVER USING BOTH HANDS.

STRAIGHT AIR SYSTEM

PROTECTED TRACTOR

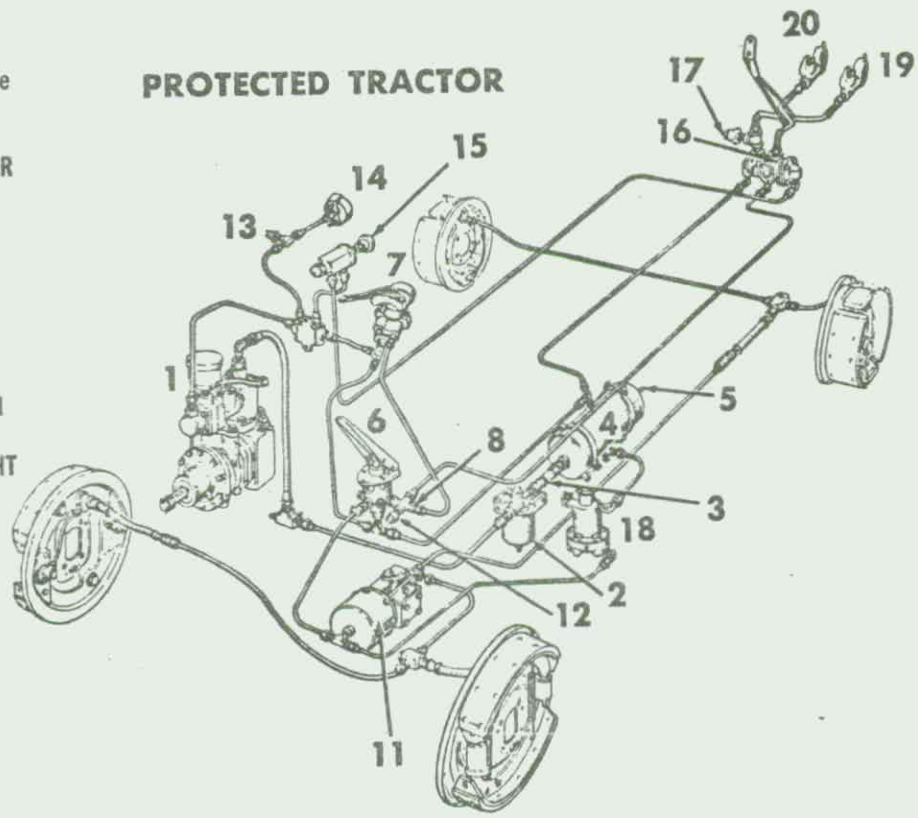


1. **COMPRESSOR** (includes control valve)
2. **ALCOHOL INJECTOR**—Accessory option
3. **SINGLE CHECK VALVE**
4. **AIR TANK**
5. **RESERVOIR SAFETY VALVE**
6. **FOOT APPLICATION VALVE**
7. **HAND APPLICATION VALVE** Accessory option
8. **TWO-WAY CHECK VALVE** Accessory option
9. **QUICK-RELEASE VALVE (shown)** or optional Tee

AIR-OVER-HYDRAULIC SYSTEM

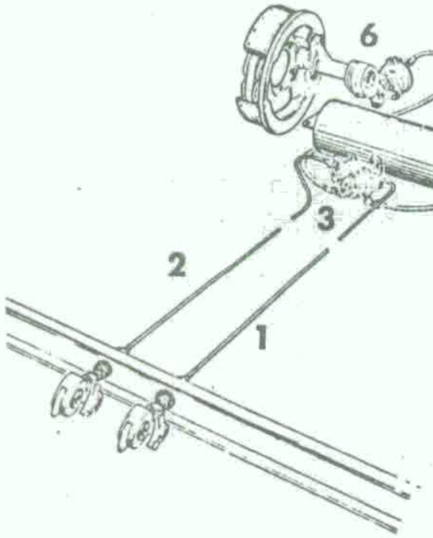
10. **RELAY QUICK-RELEASE VALVE (shown)** or optional Quick-Release Valve or Tee
11. **BRAKE CHAMBER and SLACK ADJUSTER** (straight-air) **or POWER CLUSTER** (air-over-hydraulic)
12. **SWITCH, NORMAL STOP LIGHT CIRCUIT**
13. **SWITCH, LOW PRESSURE INDICATOR CIRCUIT**
14. **AIR GAUGE**
15. **EMERGENCY BRAKE VALVE**
16. **TRACTOR AIR LINE PROTECTION VALVE**
17. **SWITCH, EMERGENCY STOP-LIGHT CIRCUIT**
18. **MOISTURE EJECTION VALVE** Accessory option
19. **EMERGENCY AIR LINE and HOSE COUPLER**
20. **SERVICE AIR LINE and HOSE COUPLER**

PROTECTED TRACTOR

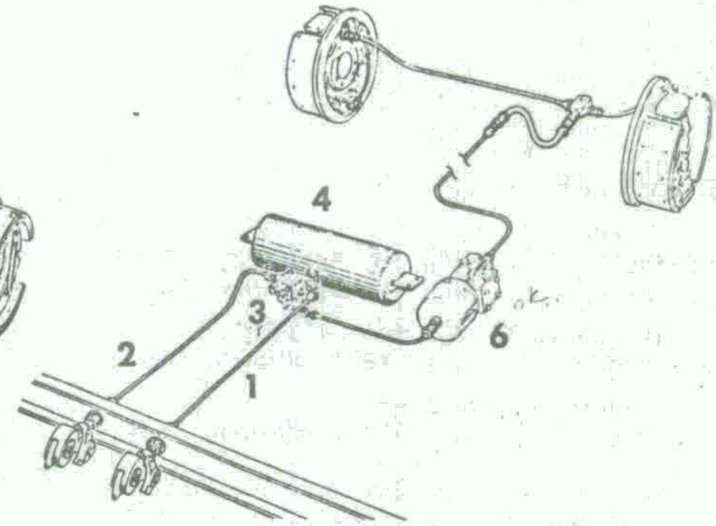


AIR BRAKE SYSTEMS

PROTECTED SEMI-TRAILER



STRAIGHT AIR SYSTEM



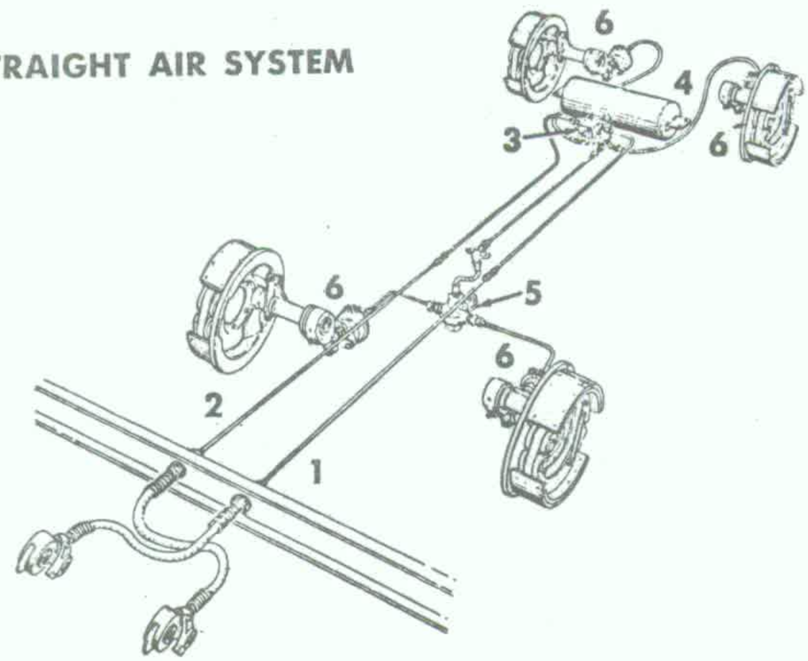
AIR-OVER-HYDRAULIC SYSTEM

1. EMERGENCY AIR LINE
2. SERVICE AIR LINE
3. RELAY QUICK-RELEASE EMERGENCY (BREAKAWAY) VALVE

PROTECTED FULL TRAILER

4. CLOSE-COUPLED TRAILER TANK
5. QUICK-RELEASE VALVE (shown) or optional Tee
6. BRAKE CHAMBER and SLACK ADJUSTER (straight-air) or POWER CLUSTER (air-over-hydraulic)

STRAIGHT AIR SYSTEM



AIR APPLICATION VALVES

TYPE FF

TREADLE VALVE

Standard Valve

AE31770 . . . . w/⅜"-18 Application Ports
AE31865 . . . . w/½"-14 Application Ports

PUSH VALVE

Standard Valve

AE31680 . . . . w/⅜"-18 Application Ports
AE31863 . . . . w/½"-14 Application Ports

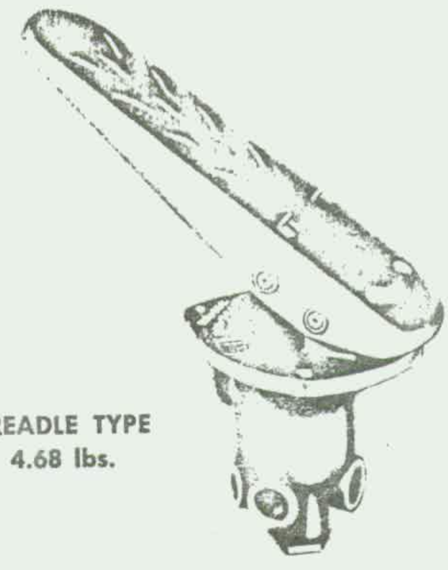
With Threaded Push Rod — ½"-20 Thread

AE34290 . . . . w/⅜"-18 Application Ports

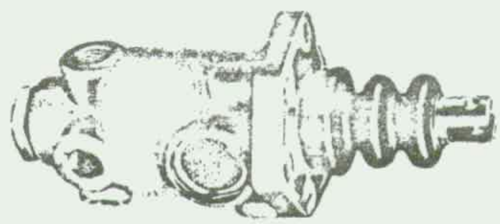
With Elliptical Mounting Flange — 2 Hole

AE33990 . . . . w/½"-14 Application Ports

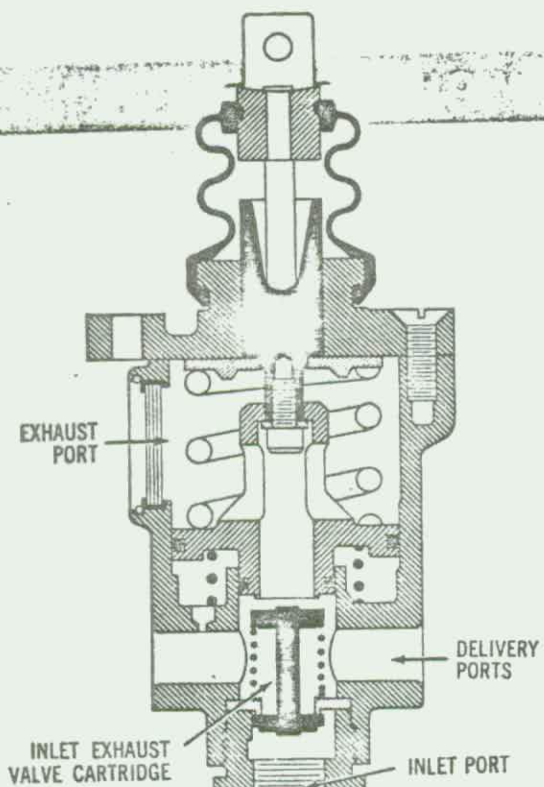
The new type FF foot application valve is a corrosion resistant unit which is both smaller and lighter than equivalent old style valves, yet maintains the same high capacity performance. The type FF application valve has a graduated metering range. Normal braking pressures in the 5 to 75 psi range are metered in exact proportion to foot pressure and pedal movement. Above 75 psi the full tank pressure is "dumped" for emergency braking.



TREADLE TYPE
4.68 lbs.



PUSH TYPE
3.25 lbs.



Valve illustrated in "released" position

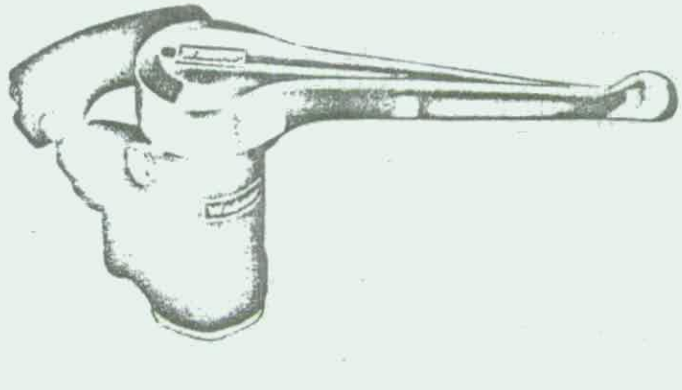
Controlling force, applied at the valve push rod and transferred through a piston stem and metering spring, strokes the application piston against its return spring. During the stroke, the piston picks up the spring loaded inlet-exhaust valve cartridge. The centered exhaust passage in the piston is closed as the piston meets the cartridge exhaust (inner) poppet and then the continuing stroke unseats the inlet (outer) poppet, admitting compressed air into the application system. Applied air also by-passes to the piston through an equalization orifice. Pressure building against the piston forces it to move back upon the stem, compressing the metering spring. The piston is balanced by these opposing forces as its lapping action permits the spring load to close the inlet poppet while holding the exhaust poppet seated on the piston. The unit remains poised in this "holding" position until another movement of the push rod unbalances it, either to admit increased air pressure or to exhaust the system.

The valve meters pressure up to approximately 75 psi. Above this pressure the piston stem and piston bottom, lap is prevented, the inlet poppet remains fully open and tank pressure is applied.

HAND OPERATED AIR APPLICATION VALVE

TYPE HE—Trailer Control

Valve Part No. *AE43769, w/Bracket
Valve Part No. *{AE25340, w/Bracket
{AE25816, w/o Bracket
*** Different Handle positions**



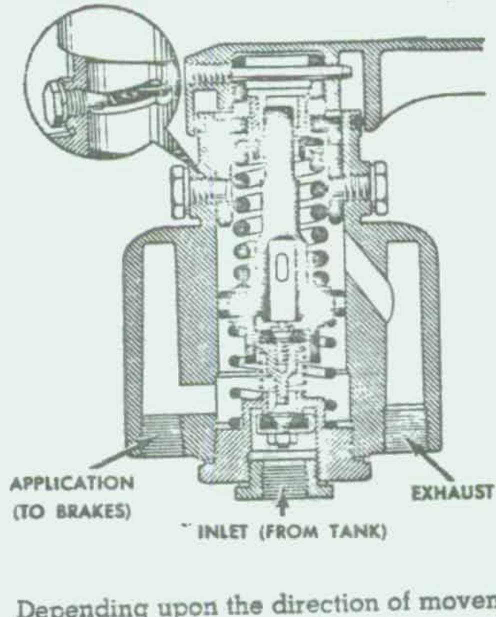
This metering type hand control valve regulates braking air pressure in direct proportion to hand pressure and movement. Braking effort balances every movement of the control valve handle. Resistance increases or decreases with the braking effort and handle "feel" provides the driver with a braking "gauge" to secure a smooth stop throughout the range from slow to emergency deceleration.

The Wagner Air Brake Trailer Control Valve provides the driver with independent metered control of the trailer brakes on combination vehicles. If the tractor is equipped with air brakes, the foot application valve also operates the trailer brakes in conjunction with the tractor brakes. In this dual system, a two-way check valve separates hand valve and foot valve so that no application pressure escapes through the exhaust port of the valve not in use.

Weight, w/o bracket . . . 3.5 lb.
w/ bracket . . . 3.8 lb.

HOW THE VALVE WORKS

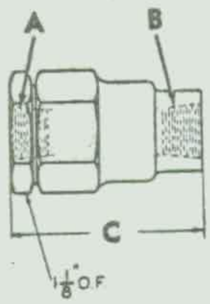
The valve is in exhaust position (handle rotated counterclockwise) and the application side of the system is open to atmosphere until the brake application cycle starts. Clockwise movement of the handle rotates the actuating cam downward as cam ramps slide on pins threaded into the valve body. Downward thrust is transferred to the metering piston through a travel adjusting nut and metering spring. The piston is forced down, closing the exhaust valve to seal the system from atmosphere. Further movement forces open the inlet valve mounted on the exhaust valve stem. Tank air pressure now flows past the inlet valve and through the outlet port, applying the brakes. Applied air pressure also builds against the face of the metering piston and cup, opposing the downward thrust. Increasing pressure returns the piston and cup until compression of the metering spring balances application pressure against pressure on the handle. As the piston returns, the valve return spring holds the exhaust valve seated while closing the inlet valve at the balanced braking pressure. Additional handle movement forces the piston and metering spring to compensate the increase or decrease by moving to relieve the unbalanced pressure condition.



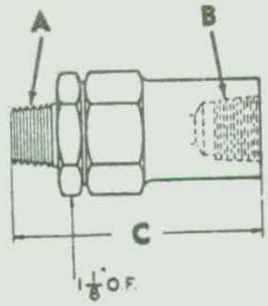
Depending upon the direction of movement, applied air pressure is either increased or exhausted to atmosphere.

SINGLE CHECK VALVES

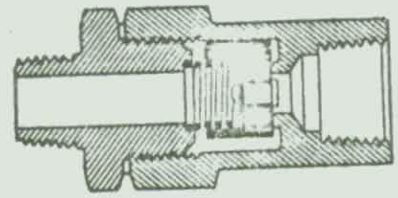
TYPE SA



Part No. AC267
Weight 0.5 lbs.



Part Nos. AC16739, 23540, 40574
Weight 0.6 lbs.

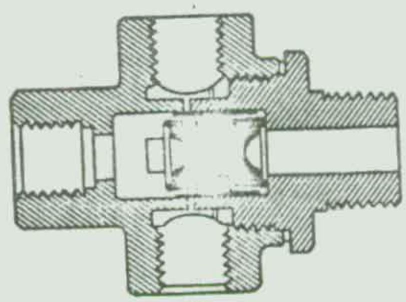


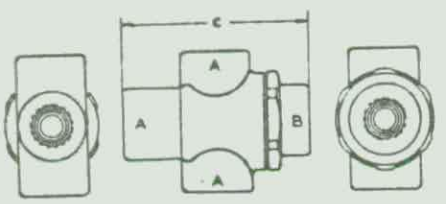
Tubing Size	Thread "A"	Thread "B"	Length "C"	Part Number
3/8"	1/4 - 18 Female	1/4" - 13 Female	2-6/32"	AC267
1/2"	3/8" - 18 Male	3/8" - 18 Female	2-25/32"	AC16739
5/8", 3/4"	1/2" - 14 Male	1/2" - 14 Female	3-3/32"	AC23540
3/4"	3/4" - 14 Male	3/4" - 14 Female	3-7/32"	AC40574

TWO-WAY CHECK VALVES

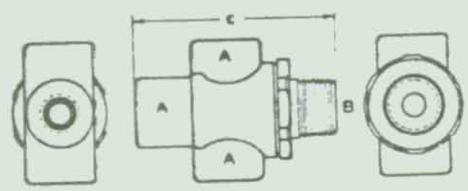
TYPE WB

Weight 0.6 lbs.





FOUR FEMALE PORTS

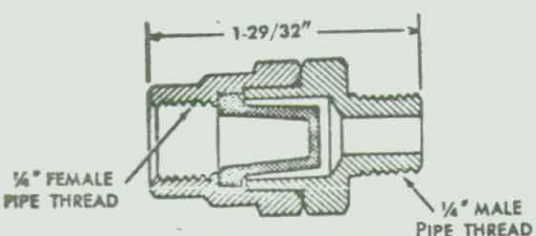


1 MALE • 3 FEMALE PORTS

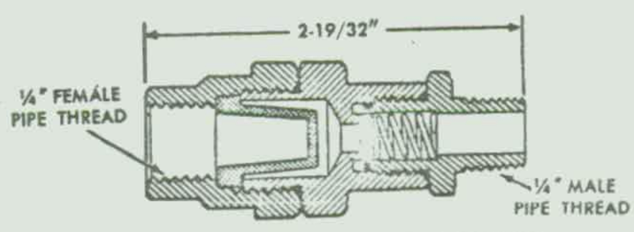
Tubing Size	Thread "A"	Thread "B"	Length "C"	Part Number
1 MALE AND 3 FEMALE PORTS				
3/8"	1/4"-18 Female	1/2"-14 Male	2-7/8"	AC32917
3/8"	1/4"-18 Female	3/8"-18 Male	2-7/8"	AC32940
3/8"	3/8"-18 Female	1/2"-14 Male	2-7/8"	AC43755
FOUR FEMALE PORTS				
3/8"	1/4"-18 Female	1/4"-18 Female	2-41/64"	AC32922
3/8"–1/2"	1/4"-18 Female	3/8"-18 Female	2-41/64"	AC32938
3/8"	*1/4"-18 Female	†1/4"-18 Female	2-41/64"	AC35893
3/8"	*1/4"-18 Female	1/4"-18 Female	2-41/64"	AC36709
3/8"	**3/8"-18 Female	3/8"-18 Female	2-41/64"	AC40522
3/8"	3/8"-18 Female	3/8"-18 Female	2-41/64"	AC43912

* One outlet contains AC25134 Pipe Plug.
** One outlet contains AC31283 Pipe Plug.
† Outlet contains 1/4" Close Pipe Nipple—7/8" long.

AIR LINE FILTERS



AIR FILTER — AC27370
Weight 0.2 lbs.

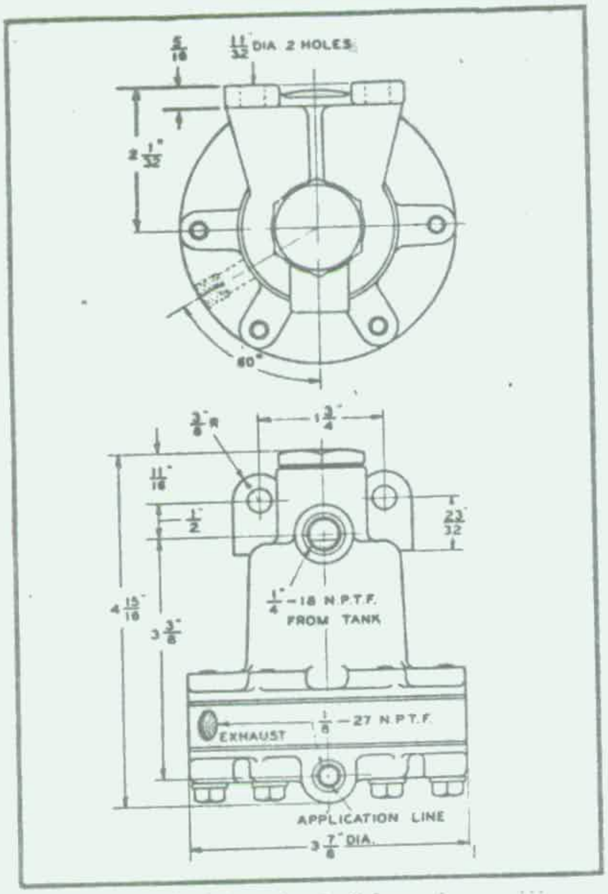


AIR FILTER & CHECK VALVE—AC27375
Weight 0.3 lbs.

MOISTURE EJECTION VALVE

Part No. AE21857
Weight 1.85 lbs.

Air reservoirs are kept clean and dry when the air brake system is equipped with a moisture ejection valve preventing the accumulation of moisture and sludge in the air tanks. Fully automatic, operating in the 15-25 psi pressure range, the unit mounts in any convenient location. It is connected into the air system by two air lines—one leading from the bottom of the air tank, the other from a brake application line. Normal brake applications operate the valve, keeping the reservoir clean and moisture-free. Expulsions occur without a noticeable drop in guuge pressure.



PERFORMANCE FEATURES

POSITIVE OPERATION — Average 15—25 psi brake application pressures guarantee frequent ejection to keep tank clean and dry. Valve ejects only upon pressure release. High application pressures do not harm the valve.

HIGH CAPACITY—Valve capacity is sufficient to eject up to four fluid ounces at one time, far more than will ever be required in any operation.

NO AIR PRESSURE LOSS—Ejection requires little air and does not cause a noticeable drop in gauge pressure. Working pressures cannot "balance" the valve in open position and "dump" reservoir pressure.

OPEN TO ATMOSPHERE—Valve fluid cavities are open to atmosphere. It is impossible to trap moisture within the unit and the valve will not freeze in open (exhaust) position.

CONSTRUCTION FEATURES

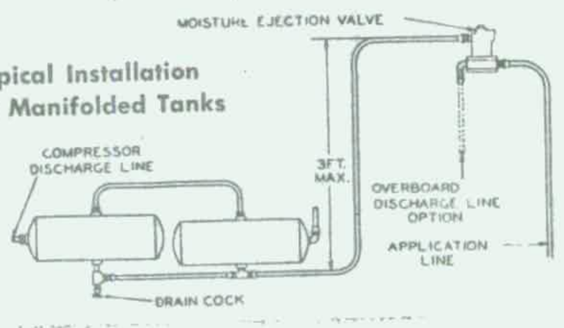
DIAPHRAGM — Nylon cord and neoprene rubber combined, oil resistant and long lived.

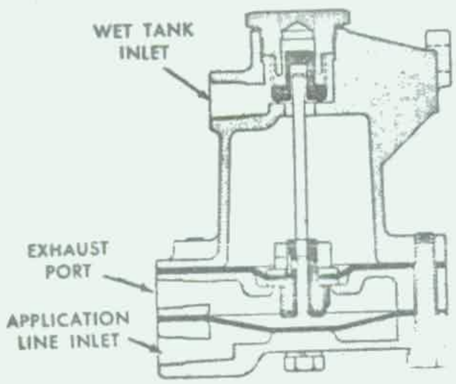
INLET VALVE INSERT—Resilient synthetic insert. Valve never requires lapping and seats better with use. Small particles of carbon and foreign matter are ejected without causing valve leakage because the insert seals around particles trapped on the valve seat.

CORROSION RESISTANT—All metal parts are made of corrosion resistant materials or are plated to prevent rust. Housing is of aluminum alloy.

CONVENIENT MOUNTING—Valve may be mounted in any location up to three feet higher than the air tank. It may be located inside the vehicle body with an overboard discharge line attached to the tapped exhaust port.

Typical Installation with Manifolded Tanks

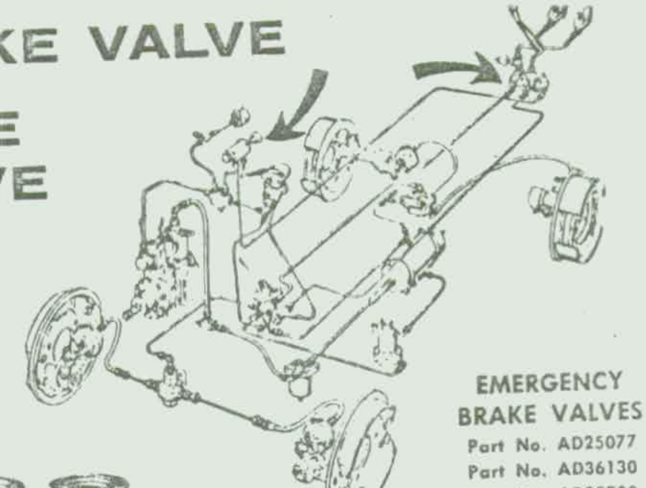




Applied air pressure forces the lower diaphragm upward to seat on and close the exhaust valve. Further upward movement raises exhaust valve and stem, opening the inlet valve. Reservoir pressure forces fluid and air mixture from bottom of reservoir to pass inlet valve and into fluid chamber where it is momentarily trapped. Release of application pressure permits pressure of trapped mixture to force exhaust valve diaphragm downward, permitting inlet valve to close. Continued releasing action moves lower diaphragm away from seat on exhaust valve and mixture is blown through valve and exhaust port. Valve remains open to atmosphere until the next application cycle.

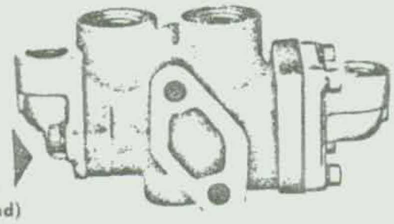
■ EMERGENCY BRAKE VALVE

■ TRACTOR AIR LINE PROTECTION VALVE



Vehicle protection utilizes two valves installed on the tractor. The emergency brake valve is a manual triggering unit for emergency braking the trailer. The air line protection valve seals off both the emergency and the service air lines on the tractor in response to the manual triggering unit or automatically if the trailer is uncoupled, breaks away, or loses its air supply.

EMERGENCY BRAKE VALVES
Part No. AD25077
Part No. AD36130
Part No. AD39300

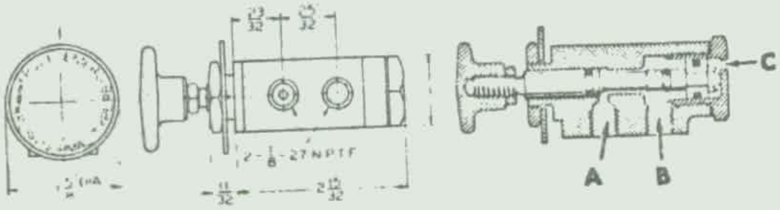


TRACTOR AIR LINE PROTECTION VALVES
Part No. AC24912 (1/2" Thread)
Part No. AC24901 (3/8" Thread)

PUSH-PULL . . . TYPE PB . . . Part No. AD25077

Weight 0.4 lb.

Used with the Tractor Protection Valve To Meet I.C.C. Regulations

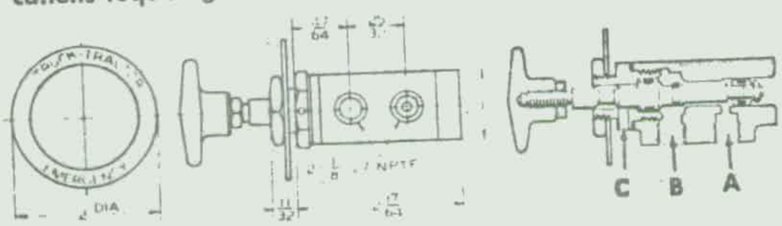


When the valve knob is pushed in, air is allowed to pass from the reservoir through Port "A" and out Port "B" to application point. When the valve knob is pulled out, Port "A" is sealed off from Port "B" and applied air pressure from Port "B" is allowed to exhaust to atmosphere at Port "C", which applies trailer brakes.

PULL-PUSH . . . TYPE XB . . . Part No. AD36130

Weight 0.4 lb.

Reverse action of AD25077 used in specific applications requiring a non-metering "off-on" action.

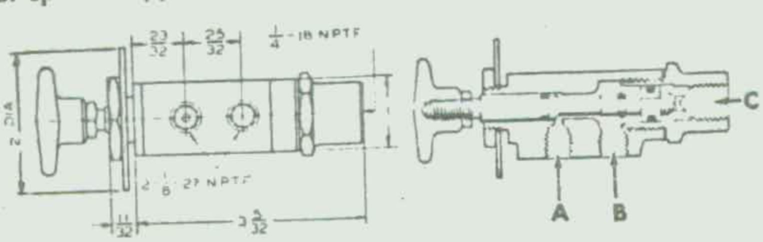


When the valve knob is pulled out, air is allowed to pass from the reservoir through Port "A" and out Port "B" to application point. When the valve knob is pushed in, Port "A" is sealed off from Port "B" and applied air pressure from Port "B" is allowed to exhaust to atmosphere at Port "C".

PUSH-PULL . . . THREE WAY VALVE . . . Part No. AD39300

Weight 0.5 lb.

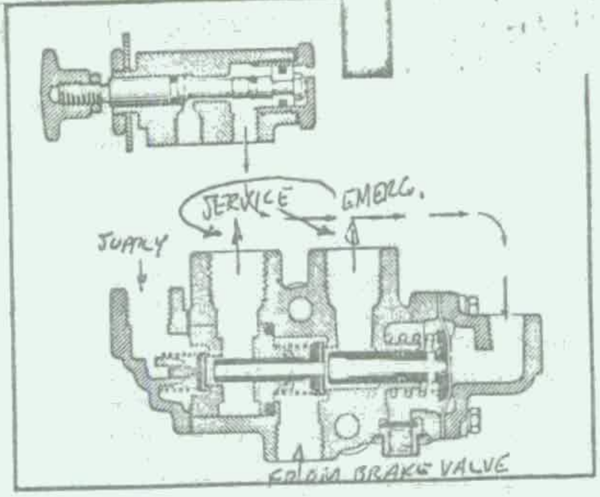
Identical action as AD25077 with the exception of a third port for specific applications requiring a non-metering "off-on" action.



When the valve knob is pushed in, air is allowed to pass from the reservoir through Port "A" and out Port "B" to application point. When the valve knob is pulled out, Port "A" is sealed off from Port "B" and applied air pressure from Port "B" is allowed to exhaust through threaded Port "C".

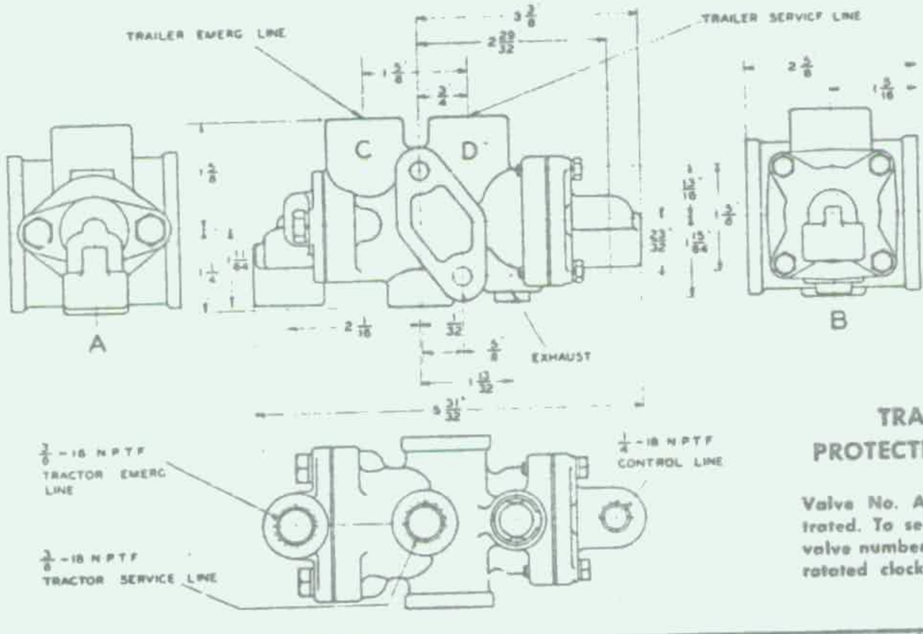
EMERGENCY BRAKE VALVE — The emergency brake valve, mounted in the tractor cab, provides "push-pull" manual control for reacting the emergency protection system on the tractor and for applying the trailer brakes in an emergency. When the emergency brake valve knob is pushed in (normal position with trailer connected) a control line is charged with air at tractor reservoir pressure. A pull on the valve knob (emergency position with trailer connected or normal position with bob-tailed tractor) vents the control line to atmosphere and seals off the air line from the tractor reservoir. It is necessary for the driver to depress this knob when picking up a trailer and to pull out the knob when dropping a trailer.

TRACTOR PROTECTION VALVE — The tractor air line protection valve is installed into service and emergency air lines leading to the trailer, replacing individual hand operated shut-off cocks. It seals these air lines in an emergency and also in normal bob-tailed operation of the tractor. In normal operation with trailer connected, reservoir pressure in the control line unseats the valve diaphragm and plunger, compressing a trigger spring to hold open check valves located in the tractor service and emergency air lines leading to the trailer. Loss of air pressure in the control line due to an emergency or in normal bob-tailed tractor operation reverses this action. The trigger spring then forces plunger and diaphragm to seat, permitting tractor service and emergency air line check valves to seal closed. The movement of these valves toward their seats also vents the trailer emer-



gency line to atmosphere through passages centered in the service line valve stem and the plunger. Air is exhausted through a check valve located in the valve body exhaust port. The exhaust port check valve speeds valve reaction in a "slow bleed down" pressure loss type failure by momentarily trapping some emergency line pressure under the diaphragm to assist the trigger spring. Remaining trailer emergency line pressure is quickly vented to start emergency braking the trailer.

Should the driver fail to use the manually operated emergency brake knob, the air line protection valve automatically reacts to seal tractor air lines and start trailer emergency braking as control line pressure drops to approximately 40-30 psi. Normal operation resumes when tractor reservoir pressure is restored to between 45 and 65 psi.



Weight 1.8 lb.

TRACTOR AIR LINE PROTECTION VALVE TYPE TC

Valve No. AC24912 and AC24901 illustrated. To select other cap positions—use valve number listed for caps "A" and "B" rotated clockwise as follows:

TRAILER HOSE PORTS "C" - "D"		Valve cap Positions	
3/8"-18 Thrd.	1/2"-14 Thrd.	"A"	"B"
AC24901	AC24912	0	0°
AC24902	AC24913	0°	90°
AC24903	AC24914	0°	180°
AC24904	AC24915	0	270°

TRAILER HOSE PORTS "C" - "D"		Valve cap Positions	
3/8"-18 Thrd.	1/2"-14 Thrd.	"A"	"B"
AC24316	AC24792	180°	0
AC24905	AC24916	180°	90°
AC24906	AC24917	180°	180°
AC24907	AC24918	180°	270°

PERFORMANCE AND CONSTRUCTION FEATURES

MINIMIZES BRAKE RESPONSE TIME—with increased flow areas, interior streamlining, and efficient "quick-release".

PREVENTS PREMATURE MOVEMENT—until a safe operating pressure is reached.

ELIMINATES UNNECESSARY "DYNAMITING"—by metering emergency braking in proportion to the loss of system pressure.

GIVES INSTANT "FULL-EMERGENCY" ACTION—in event of complete breakaway or severance of the emergency air line.

GIVES POSITIVE PRESSURE PROTECTION—sealing off the trailer reservoir should the tractor air supply become too low for safety.

HAS PISTON-SMOOTH RELAY ACTION—with extra large, 4-inch piston.

IS FULLY CORROSION-RESISTANT

HAS CARTRIDGE TYPE VALVE COMPONENTS—for quick and easy servicing on the vehicle.

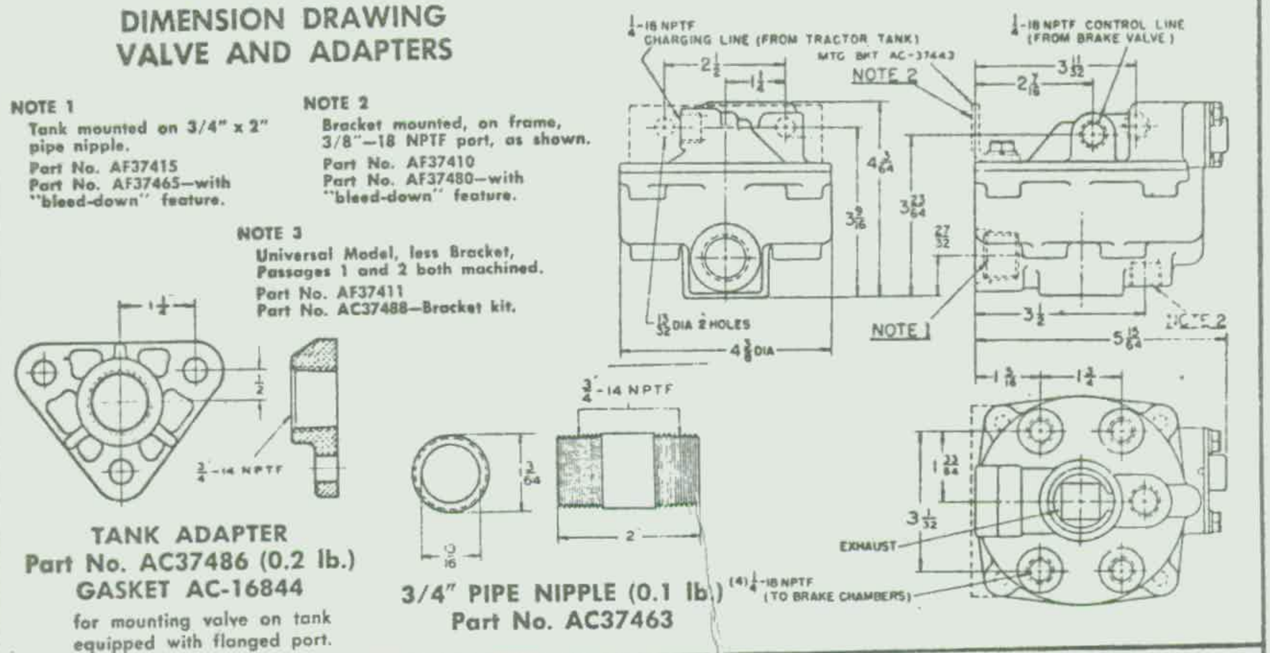
MEETS ALL I.C.C. REGULATIONS

DIMENSION DRAWING VALVE AND ADAPTERS

NOTE 1
Tank mounted on 3/4" x 2" pipe nipple.
Part No. AF37415
Part No. AF37465—with "bleed-down" feature.

NOTE 2
Bracket mounted, on frame, 3/8"—18 NPTF port, as shown.
Part No. AF37410
Part No. AF37480—with "bleed-down" feature.

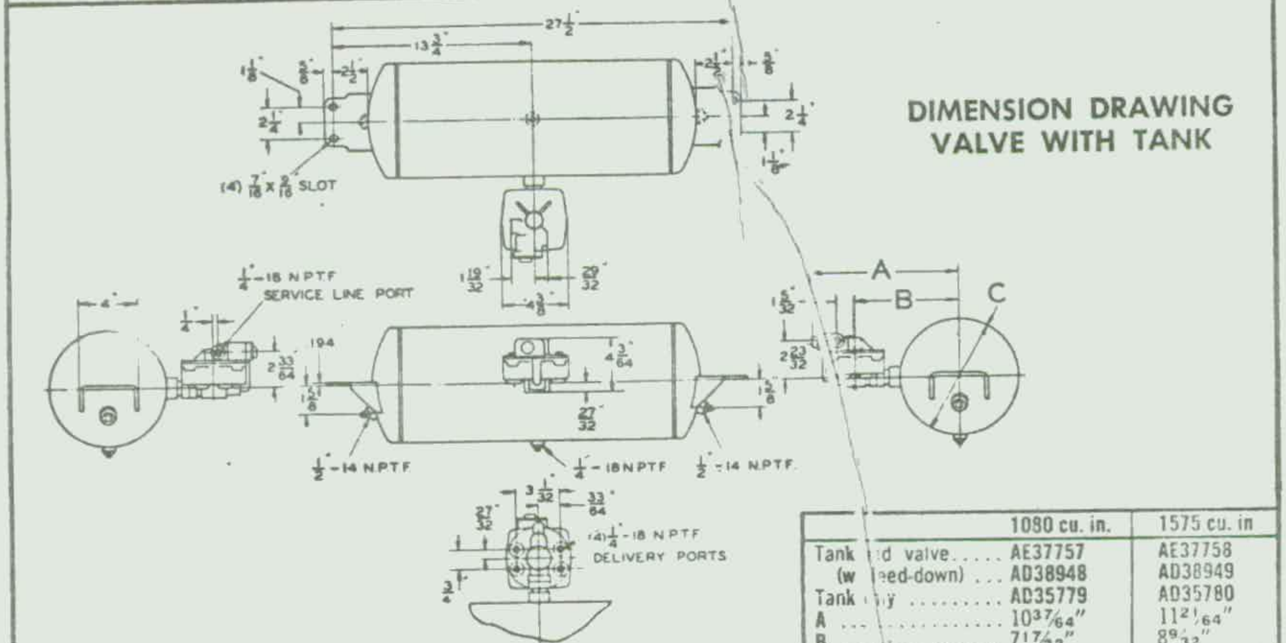
NOTE 3
Universal Model, less Bracket, Passages 1 and 2 both machined.
Part No. AF37411
Part No. AC37488—Bracket kit.



TANK ADAPTER
Part No. AC37486 (0.2 lb.)
GASKET AC-16844
for mounting valve on tank equipped with flanged port.

3/4" PIPE NIPPLE (0.1 lb.)
Part No. AC37463

DIMENSION DRAWING VALVE WITH TANK

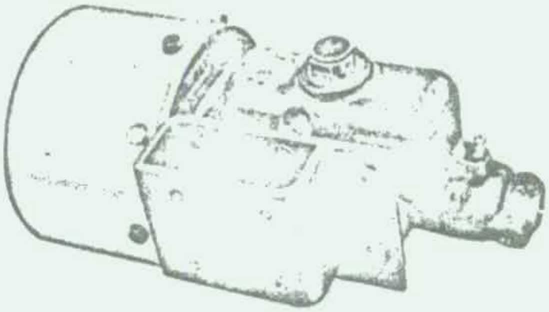


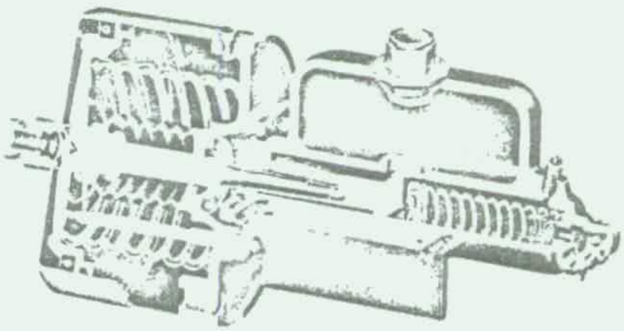
	1080 cu. in.	1575 cu. in
Tank and valve	AE37757	AE37758
(w bleed-down)	AD38948	AD38949
Tank only	AD35779	AD35780
A	10 37/64"	11 21/64"
B	7 17/32"	8 9/32"
C	8 3/16 O.D."	9 11/16 O.D."
Weight	22.81 lbs.	25.21 lbs.

AIR-OVER-HYDRAULIC POWER CLUSTER

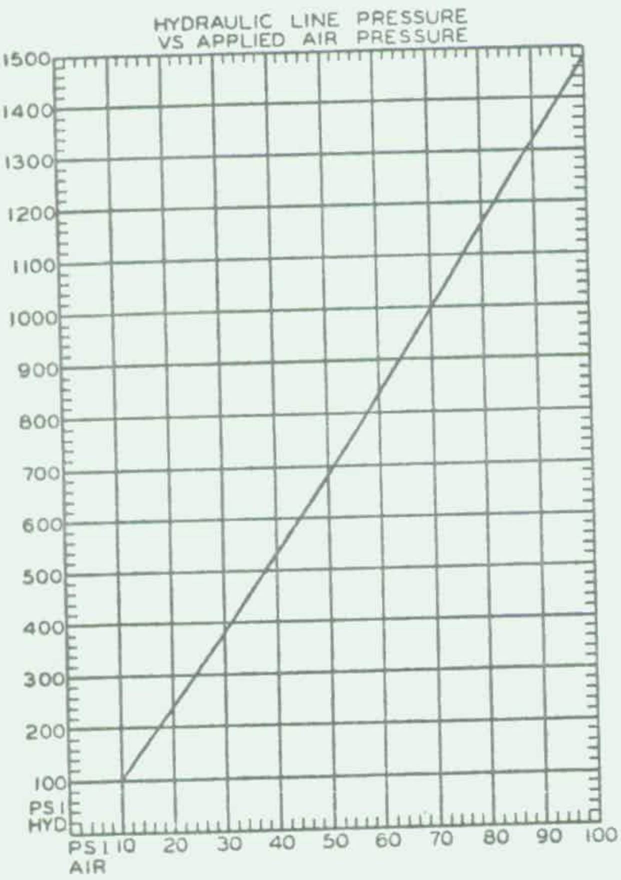
AIR CYLINDER TYPE

Stroke	Cylinder I.D.		Power Cluster Part No.
	Hydraulic	Air	
2 9/16"	1¾"	7"	AF-840
2 9/16"	1¾"	7"	AF-43943
1½"	1¾"	7"	AF-839
1½"	1½"	6"	AE-838
1½"	1¼"	5"	AE-837





The power cluster is used in air-over-hydraulic brake systems to effect the transition from moderate applied air pressures to relatively high hydraulic pressures required for hydraulic braking. Air pressure entering the unit forces an air cylinder piston and push rod to stroke a standard hydraulic brake master cylinder. Hydraulic pressure is built in 15:1 ratio to the amount of applied air pressure. Optional use of additional power clusters provides independent hydraulic systems on specific axles and prevents complete loss of vehicle braking in the event of a hydraulic component failure.



PERFORMANCE FEATURES

1500 PSI MAXIMUM PRESSURE—15:1 pressure ratio provides 1500 psi hydraulic pressure at approximately 100 psi applied air pressure.

GRADUATED CONTROL—Power cluster, used in conjunction with a metering application valve, relates braking effort directly to pedal resistance. There is no "two-stage feel" regardless of load or road conditions.

NEGLIGIBLE FRICTION LOSS—There is no linkage to increase friction loss.

BRAKE ADJUSTMENT INDICATOR—Stroke travel indicator warns of the need for lining clearance adjustment. Indicator may be used to operate a warning lamp switch.

CONSTRUCTION FEATURES

COMPACT, PROVED UNIT—The power cluster consists of a standard Wagner Lockheed hydraulic master cylinder and a single piston air cylinder engineered into a self contained, factory assembled and tested unit.

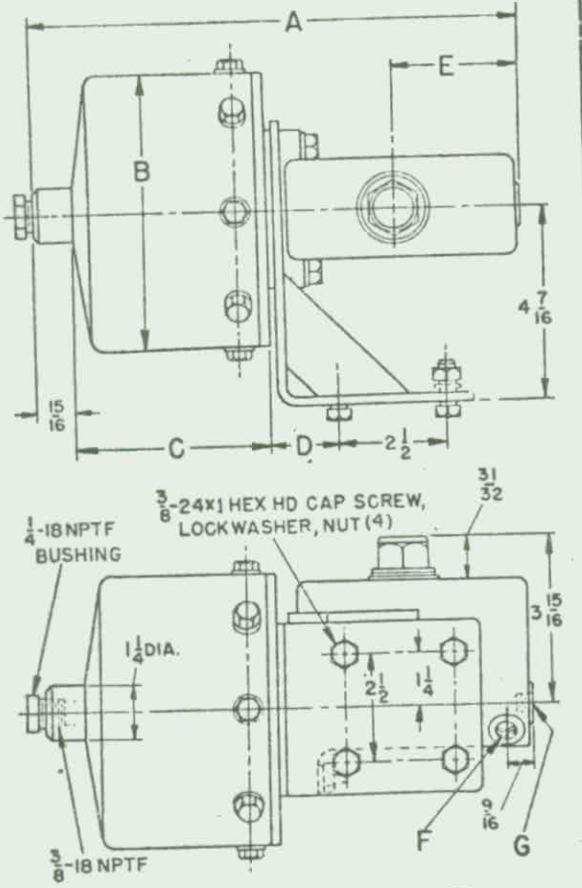
NO EXTERNAL STRESSES—Operating stresses are balanced out within the self contained unit.

SIMPLE INSTALLATION—No leverages or stresses to calculate. No levers or rods to lay out. Simply use power cluster of comparable size instead of usual brake master cylinder. Position unit in any accessible location.

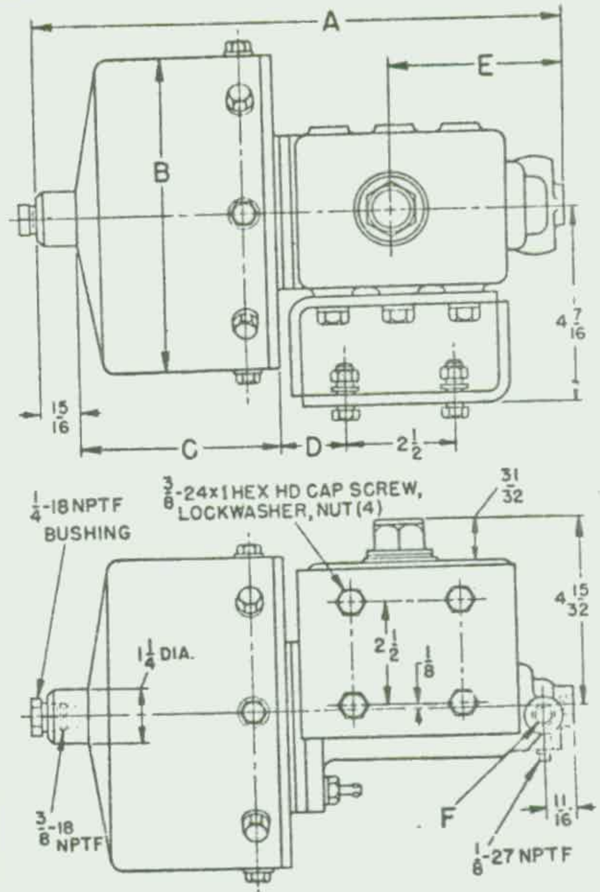
PROTECTED HYDRAULIC CYLINDER—Boot stretched between the air piston and air cylinder head excludes dust and oil from hydraulic cylinder. Air displaced on the atmospheric side of the air piston is vented through a filtered breather port.

NO CHANGE IN BRAKE BLEEDING AND MAINTENANCE—Use of the power cluster causes no change in usual brake bleeding and maintenance procedures.

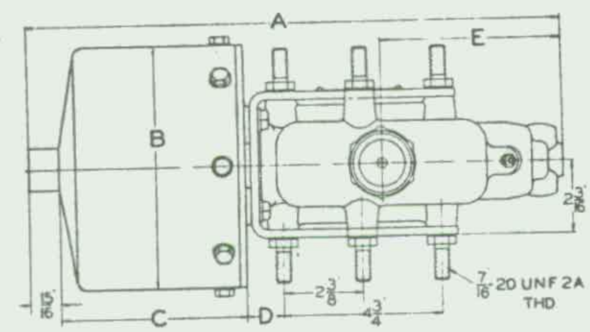
AE837 (Ord. 8017004)
AE838 (Ord. 7763611; A-8408703; 8955-7-24; 9969589)
AF839 (Ord. 9968237)
AF840 (Ord. 7763610)



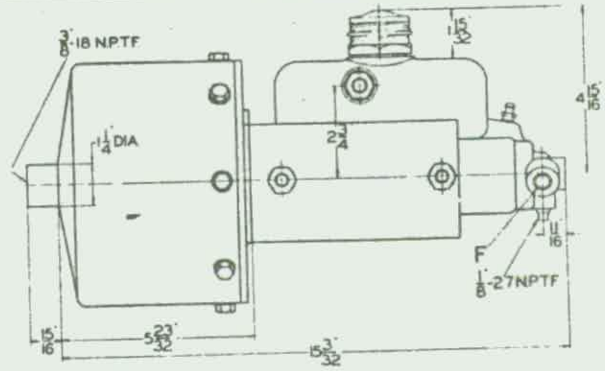
5″ and 6″ I.D. AIR CYLINDER
1-1/4″ and 1-1/2″ I.D. HYDRAULIC CYLINDER
Part Nos. AF837, AF838



7″ I.D. AIR CYLINDER
1-3/4″ I.D. HYDRAULIC CYLINDER
Part Nos. AF839, AF840



PLAN VIEW

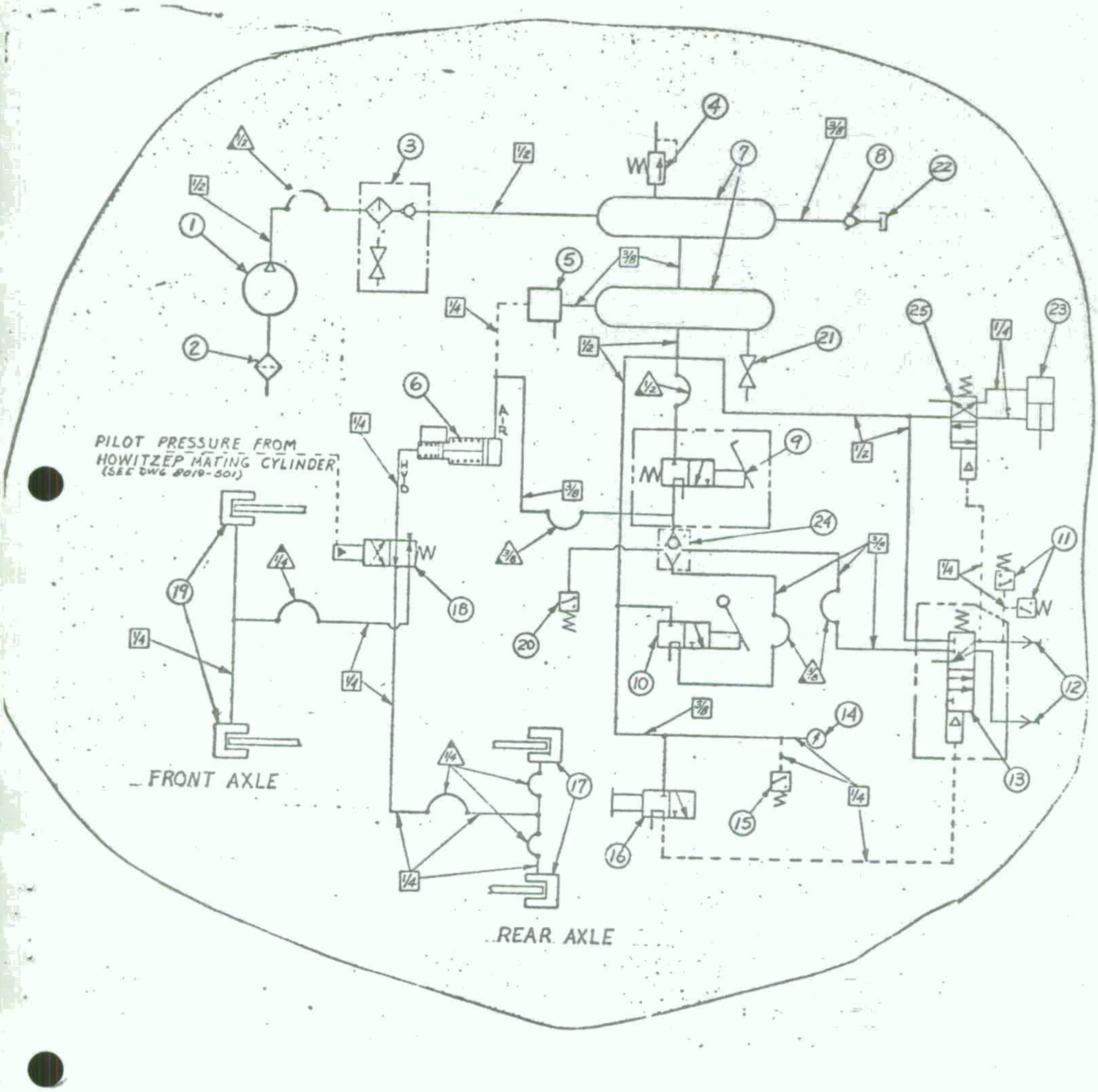


SIDE VIEW

7″ I.D. AIR CYLINDER — 1-3/4″ HYDRAULIC CYLINDER
For Off-the-Road Equipment — Part No. AF43943

Hydraulic Fluid Displacement (Cu. In.)	Stroke	Cylinder I.D.		Charted Dimensions							Weight Lbs.	Power Cluster Part No.
		Hyd.	Air	A	B	C	D	E	F (UNF-2B Thread)	G (UNF-2B or NPTF Thread)		
5.80	2 9/16″	1 3/4″	7″	16 1/32″	7 5/32″	5 9/16″	1 13/32″	5 7/16″	1/2″-20 (3)	....	31.75	AF-840
5.80	2 9/16″	1 3/4″	7″	15 3/32″	7 5/32″	5 9/16″	1 3/32″	5 7/16″	1/2″-20 (3)	....	28.00	AF-43943
3.25	1 1/2″	1 3/4″	7″	12 1/32″	7 5/32″	4 1/2″	1 13/32″	3 15/16″	1/2″-20 (3)	....	27.13	AF-839
2.40	1 1/2″	1 1/2″	6″	11 3/32″	6 5/32″	4 25/64″	1 17/32″	2 7/8″	1/2″-20 (2)	1/8″-27 (1)	20.25	AE-838 *
1.65	1 1/2″	1 1/4″	5″	11 7/32″	5 3/32″	4 17/64″	1 17/32″	3 1/8″	....	1/2″-20 (1)	17.25	AE-837

*With 5/8″—18 threaded filler cap, use assembly No. AE33478


PILOT PRESSURE FROM
HOWITZEP MATING CYLINDER
(SEE DWG 8019-501)
AIR
HYD
FRONT AXLE
REAR AXLE

PACIFIC CAR AND FOUNDRY COMPANY

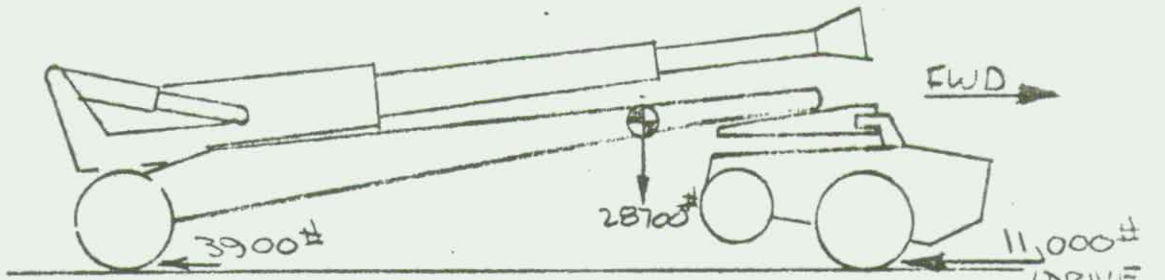
ENGINEERING DEPARTMENT

PREPARED BY [signature] ORDER NO.

CHECKED BY PAGE OF

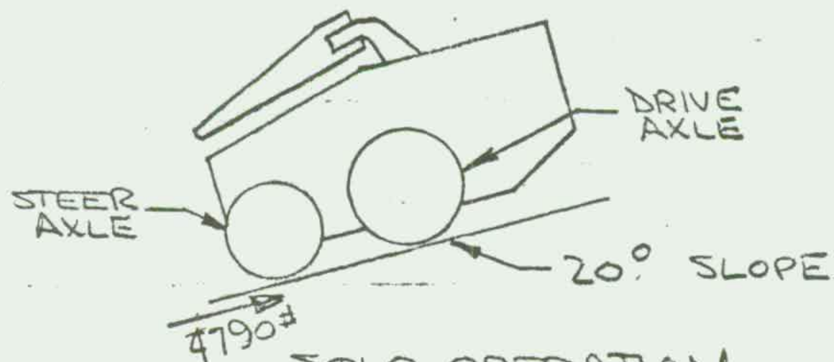
DATE 9/20/73 REPORT NO.

BRAKING REQUIREMENTS



TUG TOWING HOWITZER

1. TO STOP AT .5G FROM 35MPH REQ'S
   BRAKE TORQUE (DRIVE AXLE) = 11000#(19.3") = 213,000 LB-IN
   (μ = .6, DIST = 70.7 FT)
   WHEELS - 19.5 DIA, 13.0 WIDE, 15° DROP CENTER
   MOUNTED ON ROCKWELL-STANDARD H-140 AXLE
   (WEIGHT TRANSFER TO DRIVE AXLE INCLUDED)



SOLO OPERATION

2. TO HOLD TUG ON 20° SLOPE
   BRAKE TORQUE (STEER AXLE) = 4790#(15.4") = 73,800 LB-
   WHEELS - 16.5 DIA, 9.75 WIDE, 15° DROP CENTER

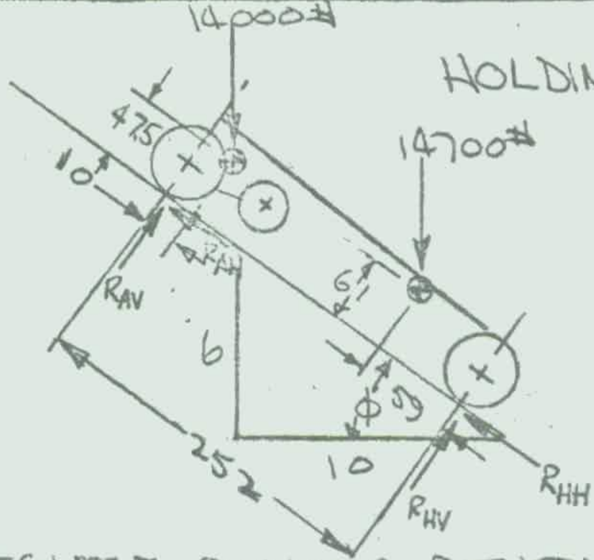
BRAKES TO BE MOUNTED INSIDE WHEELS
OPERATION BOTH ON & OFF-ROAD
AIR OVER HYDRAULIC ACTUATION (100 PSI AIR A[illegible])
(DRIVE AXLE BRAKES WILL NOT BE USED D[illegible]
SOLO OPERATION)

PCF-DN-K07

PREPARED BY HK
CHECKED BY
DATE 9/12/73
ORDER NO. ATLAS
PAGE 1 OF
REPORT NO.

BRAKING LOADS

1. HOLDING UPHILL (60% SLOPE)



NEGLECT ROLLING RESISTANCE

$$R_{HV} = \frac{14{,}000\cos\phi(10) + 14{,}000\sin\phi(47.5) + 14700[\cos\phi(193)+\sin\phi(61)]}{252}$$

$$= 13320\#$$

$$R_{AV} = \frac{14000[\cos\phi(242)-\sin\phi(47.5)] + 14700[\cos\phi(59)-\sin\phi(61)]}{252}$$

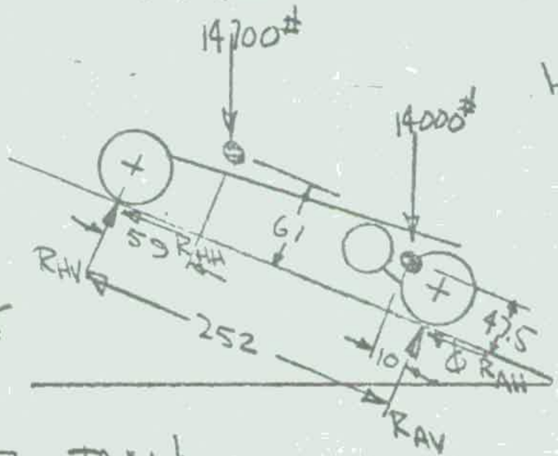
$$= 11290\#$$

$$R_{HH} = R_{HV}\tan\phi = 13320(.6) = 7990\#$$

$$R_{AH} = R_{AV}\tan\phi = 11290(.6) = 6770\#$$

2. HOLDING DOWNHILL (60% SLOPE)

NEGLECT ROLLING RESISTANCE



$$R_{AV} = \frac{14700[\cos\phi(59)+\sin\phi(61)] + 14000[\cos\phi(242)-\sin\phi(47.5)]}{252}$$

$$= 17{,}670$$

$$R_{AH} = R_{AV}\tan\phi = 17670(.6) = 10600\#$$

$$R_{HV} = \frac{14700[\cos\phi(193)-\sin\phi(61)] + 14000[\cos\phi(10)-\text{[illegible]}]}{252}$$

$$= 6940\#$$

$$R_{HH} = R_{HV}\tan\phi = 6940(.6) = 4165\#$$

PCF-RN-597

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY HJK

CHECKED BY

DATE 9/12/73

ORDER NO. ATLAS

PAGE 2 OF

REPORT NO.

HOLDING ON 60% SLOPE - WORST BRAKE REQ FOR ATLAS IS DOWN SLOPE - BRAKES MUST HOLD 10,600#

BRAKE TORQUE REQD = FR
FOR 16-19.5 TIRE R = 19.3 IN

MAX BRAKE TORQUE REQD

= 10,600 (19.3) = 205,000 LB-IN

PCF-RN-597

PREPARED BY Hyz
CHECKED BY
DATE 9/19/73

ORDER NO.
PAGE OF
REPORT NO.

HOWITZER BRAKE CAPACITY

BF GOODRICH 419-174 CALIPER
(FIXED DISC - 4 PISTON)

TANGENTIAL FORCE = 16000# @1500 PSI
BRAKING RADIUS = $\sqrt{7.12^2 + 2.125^2}$
= 7.43

MAX BRAKING TORQUE = 16,000 (7.43)(2)
= 237,600 lb-in

TO STOP @ .5 G FROM 35 MPH
TAKES .26(14900) × 19.3 = 75000#

BRAKES WILL LOCK UP - THIS IS UNSTABLE

HAVE TO LIMIT AIR PRESSURE TO
HOWITZER TO AVOID LOCK-UP
AIR-HYD BOOSTER RATIO = 15:1

AIR PRESSURE HAS TO BE LIMITED TO

$$\frac{75000}{237{,}600} \times \frac{1500}{15} = \underline{31.5 \text{ PSI}}$$

PCF-RN-597

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY S. BLACK

CHECKED BY

DATE 9/12/73

ORDER NO. ATLAS

PAGE 3 OF

REPORT NO.

3. STOP FROM 35 MPH @ .5G

ASSUMPTIONS:

1. MASS INCREASED BY 4% FOR ROTATING MEMBERS

MASS = 28,700 (1.04) / 32.2 = 926 SLUGS

2. AIR RESISTANCE: NEGLECTED

3. ROLLING RESISTANCE: NEGLECTED

4. GRADE = 0

5. DYNAMIC WEIGHT TRANSFER = 0

6. ENGINE BRAKING POWER = 0

$B_f = 16.2(m)$

Bf (BRAKING FORCE @ $\frac{1}{2}$ "G") = 16.2 (926) = 14,900 lb_f

ASSUMING $\mu = .6$

$$S_{MIN} = \frac{1.04\,(35)^2}{30\,(.6)} = 70.7 \text{ ft}$$

AXLE LOADS

ATLAS 16500# CG HT = 54.7"

HOWITZER 12,200#

BRAKE FORCE DISTRIBUTION = $\frac{L_r + H(\mu + f)}{L_f - H(\mu + f)}$ $\mu = .6$, $f = .011$

L_r = DIST. REAR AXLE TO CG. = .58L H = .217L

L_f = " FRONT " " " " = .42L

L = WHEEL BASE = 252"

204 $= \frac{.58 + .217(.6 + .011)}{.42 - .217(.6 + .011)} =$ [illegible]

74% ON ATLAS AXLE

PCF-RN-597 BRAKE FORCE ON ATLAS = .74 (14900) = 11,000

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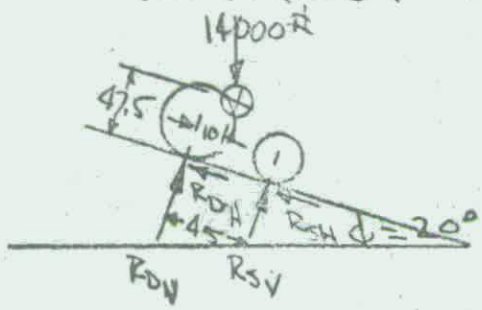
DATE 9/12/73 REPORT NO.

4. TO HOLD ATLAS ON 20° SLOPE WITHOUT HOWITZER



$$R_{SV} = \frac{14000[\cos\phi(10) + \sin\phi(47.5)]}{45}$$

$= 7980\#$ (HEADED UPSLOPE)

FACED OPPOSITE WAY ON SLOPE

$$R_{SV} = \frac{14000(\cos\phi(35) - \sin\phi(47.5))}{45} = 5160\#$$ (HEADED DOWN)

BRAKING FORCE REQD $= 14000 \sin 20°$
$= 4790\#$

SO WITH ATLAS HEADED DOWNSLOPE COEFFICIENT BETWEEN GROUND & TIRES MUST BE 4790/5160
$\geq .93$

UPSLOPE 4790/7980 $\geq .6$

BRAKE TORQUE $= 4790(15.4) = 73,800$ LB-IN

PCF-RN-597

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY [signature] ORDER NO. ATLAS

CHECKED BY PAGE 5 OF

DATE 9/12/72 REPORT NO.

BRAKING REQ'S FOR ATLAS

1. TO HOLD ATLAS & HOWITZER ON 60% SLOPE (DOWNHILL)

DRIVE AXLE BRAKE TORQUE = 205,000 LB-IN MINIMUM

STEER AXLE = 0

2. TO STOP ATLAS & HOWITZER FROM 35 MPH @ > .5 G

DRIVE AXLE BRAKE TORQUE = 213,000 LB-IN AVE
(.6 BRAKING COEF.)
DISTANCE — 70.7 FT

STEER AXLE = 0

3. HOLD ATLAS ON 20° SLOPE WITHOUT HOWITZER

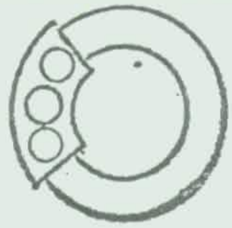
STEER AXLE BRAKE TORQUE = 73,800 LB-IN MINIMUM

PCF-RN-597

DISK BRAKES FOR PACIFIC CAR AND FOUNDRY COMPANY

CALCULATED PERFORMANCE Date 10-16-73

2 WHEEL DRIVE Job No. 565 Originator JCM

B. F. Goodrich Brake Series		REMARKS
DRIVE AXLE		
EMPTY WEIGHT	14,400 #	
LOADED WEIGHT	28,700 #	
TIRE SIZE AND TIRE RADIUS	16.5 x 19.5 19.3 In.	
MAX. SPEED LOADED	35 Mph.	
DISK SIZE AND WEIGHT	15.125 x 5 x 1 45 #	
BRAKE RADIUS IN INCHES	6.062 In.	
DIAMETER OF PISTONS AND NUMBER/VEHICLE	2-7/8 12	
TUG TORQUE LOADED	212,355 Lb-In.	SEE NOTE NO. 1
REQ. PRESSURE FOR STOP	1,215 PSI	SEE NOTE NO. 1
ACTUAL GROUND COEF. FOR STOP	.505	
MINIMUM STOP DISTANCE AT 1215 PSI.	96 Ft.	SEE NOTE NO. 2
MAX. GRADE HOLDING ABILITY AT 1215 PSI.	60 %	
NUMBER OF STOPS AT 500°F	12	SEE NOTE NO. 3
NUMBER OF STOPS AT 750°F	27	SEE NOTE NO. 3
DISK ΔT FOR LOADED STOP FROM MAX. SPEED	72.9 °F	

NOTES:

1. Brake Torque Requirements are Based on Stopping Loaded Vehicle from 35 mph, a .505G deceleration and with .3 Sec. System Delay.
2. Min. Stop Distance From 35 MPH with Loaded Vehicle and with .3 Sec. System Delay.
3. Stops Per Hour with a Loaded Vehicle from a Speed of 35 MPH without Exceeding the Disk Temperatures Shown.
4. Dynamic Lining Coefficient .37 .

F. GOODRICH GROUND VEHICLE BRAKE ENGINEERING RECOMMENDATION

Job Number Revision ______ Job Number 563
Revision Date ______ Date 10-16-73

A. Axle Mfg. Rockwell Model H-140 Tire Size 16.5 x 19.5 R 19.3

B. Vehicle Mfg. Pacific Car and Foundry Model ______ Type Tug

Number of Driven Wheels 2
Empty Weight 14,400 Loaded Weight 28,700
Loaded Axle Weight Tug - 16,500; Howitzer 12,200
Empty Axle Weight Tug Front 9,600; Tug Rear 4,800

C. Special Application Considerations or Usage Conditions Or Limitations (if any)

D. B.F. Goodrich Components. List All; and Where Used on Vehicle
Use two (2) 419-213 brakes, one per wheel to be mounted on front axle of tug.

Pressure Limitations 1500 psi. If Equipment is Proposed and no drawings is available, describe by Type, Piston Size, Similar To, and Etc.

E. Brake Application is Approved.
Signed Joe Moore W L Daniels
J.C. Moore

F. Brake Application is Approved With Qualifications as Listed Below:

Signed ______

G. Brake Application is Not Approved Because -

Signed ______

H. Axle Manufacturer Approval (when applicable) Brake Application (is) (is not) approved. Comments

ZINK ENTERPRISES
P. O. Box 771
Bellevue, Washington 98004
Phone: 206-454-8104

Signed ______, Title ______ Date ______

TOL·O·MATIC

46 10TH AVENUE SOUTH, MINNEAPOLIS, MINNESOTA 55415 • TELEPHONE: 612 335-6605

December 17, 1973

Pacific Car & Foundry
1400 N. 4th St.
Renton, WA 98055

Attn: Mr. H.G. Kirchner

Dear Mr. Kirchner,

In reference to our phone conversation today we recommend our H220 DXCIG caliper with a spacer for a 1" thick disc. Two such calipers/wheel.

As for the disc we recommend a 1" thick disc 12" in diameter. Such a disc will allow for proper heat dissapation and absorbtion.

Enclosed is the data sheet on the cast iron unit and our quotation on 400 units.

Yours truly,

W.C. Branham-gg

William C. Branham
Marketing Manager

WCB:gg

cc: Jack Ogle
M. Bress

TOL-O-MATIC
246 Tenth Avenue South
Minneapolis, Minnesota 55415
Telephone 612 335-6605

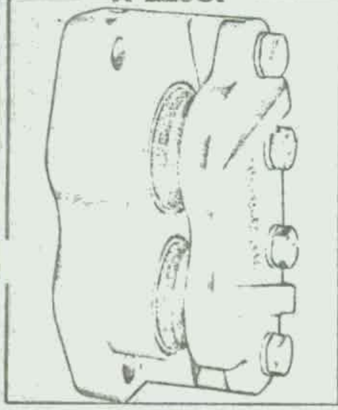
CAST IRON 220 SERIES HYDRAULIC CALIPER DISC BRAKES

For—Mining Equipment
Mobile Off-the-Road Equipment

FEATURES:

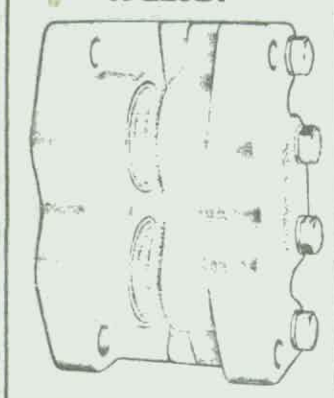
- CAST IRON HOUSINGS
- CHROMATE OVER CADMIUM RUST PREVENTIVE
- HIGH GRADE FRICTION MATERIAL
- NICKEL PLATED STEEL PISTONS
- BUNA "N" SEALS - STANDARD
  Buna "S" Seals (Available for Automotive Brake Fluids at no additional charge).
- GRADE 8 MOUNTING BOLTS, CADMIUM PLATED
- 220 SERIES PROVIDES 4 SQ. INCHES OF ACTIVE PISTON AREA AND 8 SQ. INCHES OF PUCK AREA

H 220SI



MODEL NUMBER	STOCK NUMBER	LIST PRICE	MODEL NUMBER	STOCK NUMBER	LIST PRICE	MODEL NUMBER	STOCK NUMBER	LIST PRICE
H220 SACI	0733-0301	46.86	H220 SBCI	0733-0401	49.02	H220 SECI	0733-0501	49.17
H220 SAFCI	0733-0321	55.38	H220 SBFCI	0733-0421	57.54	H220 SEFCI	0733-0521	57.69
H220 SARCI	0734-0311	47.61	H220 SBRCI	0734-0411	49.77	H220 SERCI	0734-0511	49.92
H220 SARFCI	0734-0331	57.06	H220 SBRFCI	0734-0431	59.22	H220 SERFCI	0734-0531	59.37

H 220DI



MODEL NUMBER	STOCK NUMBER	LIST PRICE	MODEL NUMBER	STOCK NUMBER	LIST PRICE	MODEL NUMBER	STOCK NUMBER	LIST PRICE
H220 DACI	0735-0401	64.00	H220 DBCI	0735-0501	64.00	H220 DECI	0735-0601	64.00
H220 DARCI	0736-0413	72.05	H220 DBRCI	0736-0511	72.05	H220 DERCI	0736-0611	72.05

LEGEND

H – HYDRAULIC ACTUATION
D – DOUBLE ACTING
S – SINGLE ACTING
A – "A" SPACER - 5/32" DISC
B – "B" SPACER - 1/4" DISC
R – RETRACTABLE PISTON(S)
F – FLOATING MOUNTING BRACKET
C – BLEEDER FITTINGS,
E – "E" SPACER 1/2" DISC
G – BUNA "S" SEALS – (Must Specify if Required)
I – CAST IRON CONSTRUCTION

H 220 SERIES TORQUE VERSUS PRESSURE

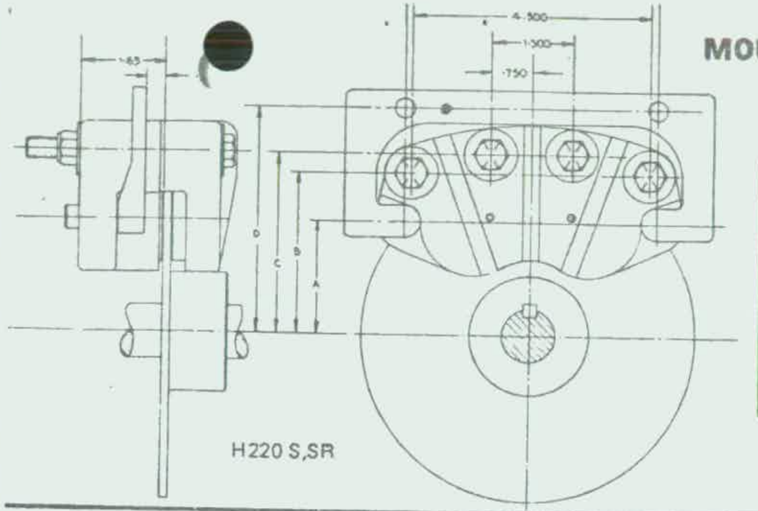
6 INCH DISC		8 INCH DISC		10 INCH DISC		12 INCH DISC		16 INCH DISC	
PSI	Torque - Inch Lbs.	PSI	Torque - Inch Lbs.	PSI	Torque - Inch Lbs.	PSI	Torque - Inch Lbs.	PSI	Torque - Inch Lbs.
100	685	100	907	100	1,184	100	1,463	100	2,076
200	1,371	200	1,814	200	2,367	200	2,926	200	4,153
500	3,427	500	4,536	500	5,918	500	7,315	500	10,382
1,000	6,854	1,000	9,072	1,000	11,837	1,000	14,630	1,000	20,765
1,500	10,282	1,500	13,608	1,500	17,755	1,500	21,946	1,500	31,147

ABOVE TORQUES BASED ON 288 LBS. OF FORCE PER 100 PSI X BRAKING RADIUS (INCHES)

(BRAKING RADII)
6 INCH DISC – 2.38
8 INCH DISC – 3.15
10 INCH DISC – 4.11
12 INCH DISC – 5.08
16 INCH DISC – 7.21

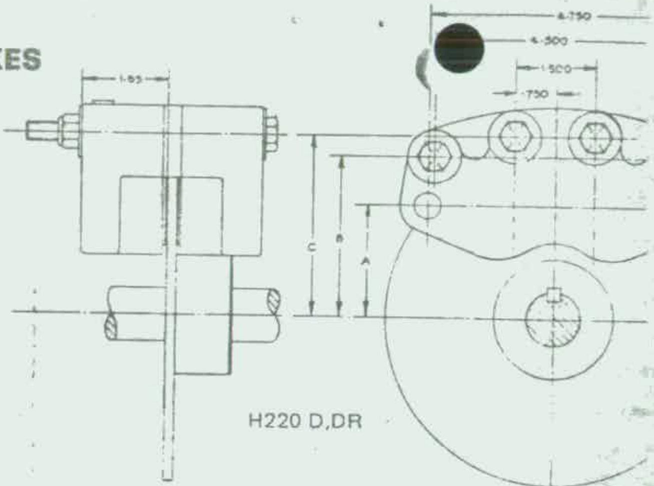
For Dimensional Data-See Other Side

MOUNTING DIMENSIONS CALIPER DISC BRAKES

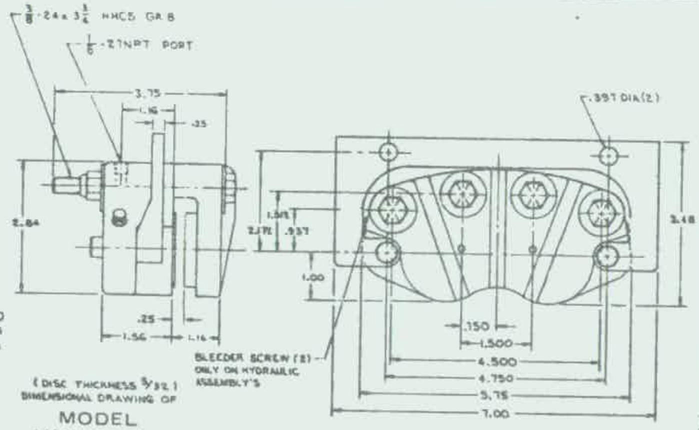


H220 S,SR

DISC. DIA. IN.	A	B	C	D
6-5/16	2.13	3.07	3.45	4.30
8	3.00	3.94	4.32	5.17
10	4.00	4.94	5.32	6.17
12	5.00	5.94	6.32	7.17
16	7.09	8.03	8.41	9.26

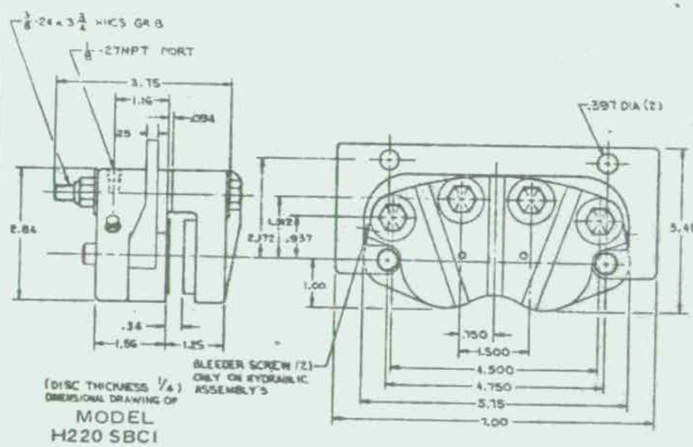


H220 D,DR



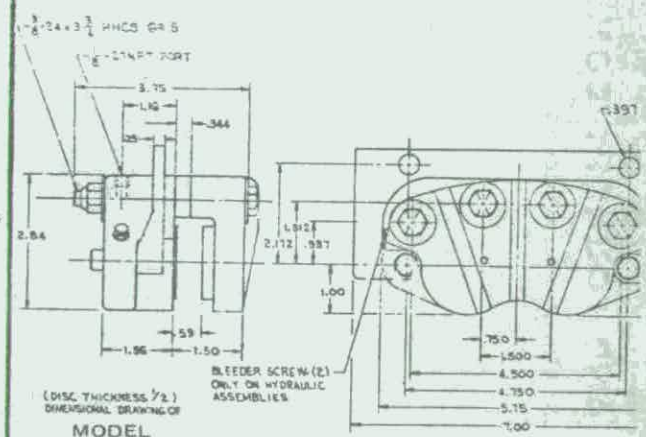
(DISC THICKNESS 3/32) DIMENSIONAL DRAWING OF

MODEL
H220 SACI
H220 SAFCI
H220 SARCI
H220 SARFCI



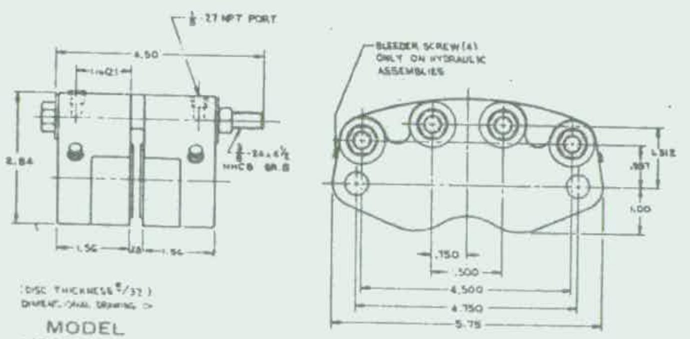
(DISC THICKNESS 1/4) DIMENSIONAL DRAWING OF

MODEL
H220 SBCI
H220 SBFCI
H220 SBRCI
H220 SBRFCI



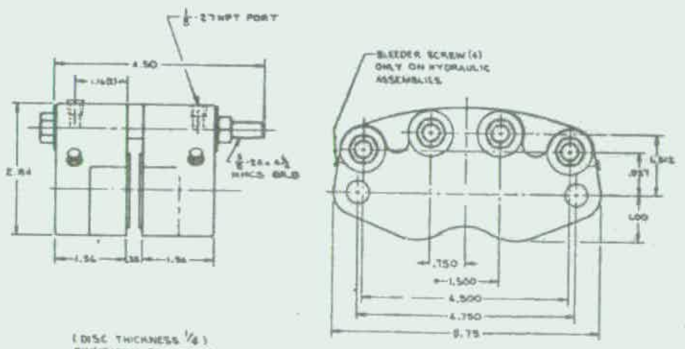
(DISC THICKNESS 1/2) DIMENSIONAL DRAWING OF

MODEL
H220 SECI
H220 SEFCI
H220 SERCI
H220 SERFCI



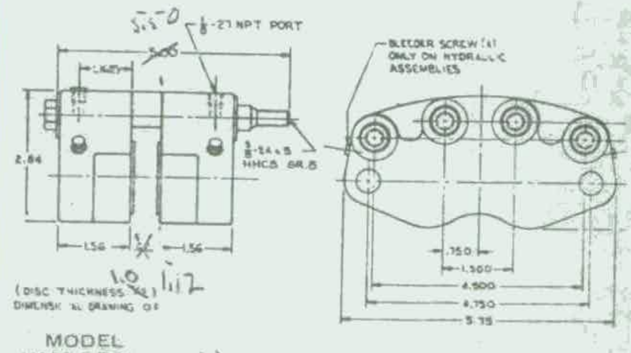
(DISC THICKNESS 3/32) DIMENSIONAL DRAWING OF

MODEL
H220 DACI
H220 DARCI



(DISC THICKNESS 1/4) DIMENSIONAL DRAWING OF

MODEL
H220 DBRCI
H220 DBCI



(DISC THICKNESS 1/2) DIMENSIONAL DRAWING OF

MODEL
H220 DECI
H220 DERCI

H220DXCIG

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

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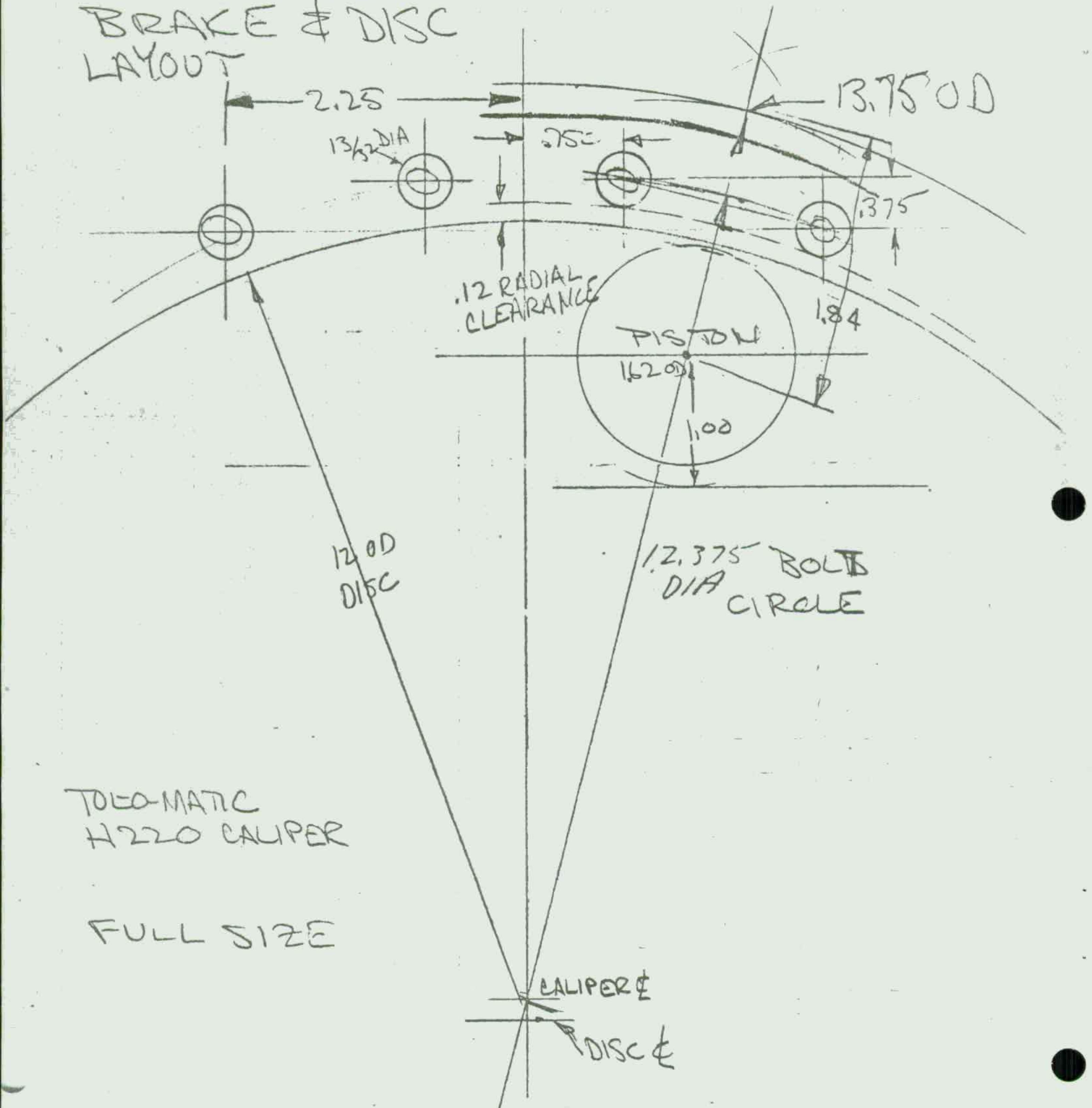
CHECKED BY__________ PAGE_____ OF_____

DATE__________ REPORT NO.__________

BRAKE & DISC LAYOUT



TOL-O-MATIC H220 CALIPER

FULL SIZE

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

PREPARED BY HJK

CHECKED BY

DATE 10/21/73

ORDER NO.

PAGE 1 OF

REPORT NO.

PARKING BRAKE

REQUIREMENT - HOLD ATLAS ON 20° SLOPE

BRAKING FORCE REQUIRED 4790#

FOR BRAKE ON DROP BOX OUTPUT

BRAKE TORQUE = $\frac{4790(19.3)}{8.2}$

= 11,300 LB-IN

MAX BRAKE DISC RADIUS = 5.5 IN

H-H PRODUCTS - KELSEY HAYES

MODEL 385M W 10" DIA ROTOR DEVELOPS ~14000 LB-IN TORQUE WITH 310# PULL ON LEVER

(ORSCHELN BRAKE LEVER MAX PULL IS 3900#)

Use B.F. Goodrich instead

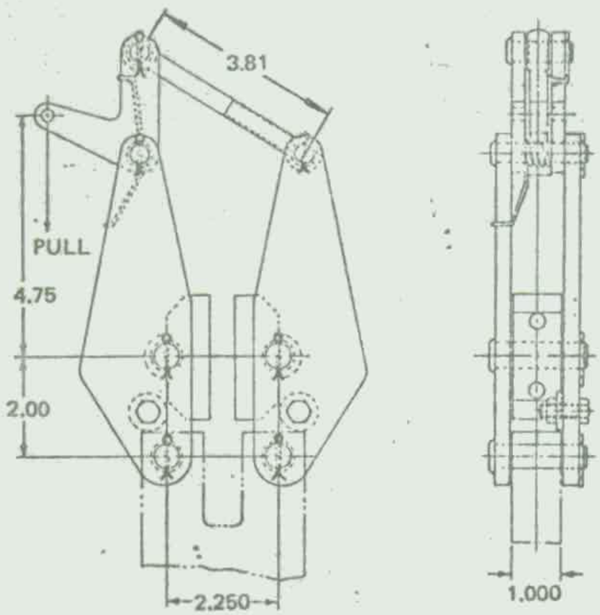
419-176

ON 4.90 BRAKE RADIUS (11.33 OD DISC)

@ MAX PULL = 1500#, TANG. BRAKE FORCE = 3000

TORQUE = 3000(4.90) = 14700 LB-IN

PCF-RN-597



BRAKE TYPE

Caliper disk, mechanically applied. (Approximate weight = 5.5 lbs.)

RECOMMENDED USE

Parking, mount on drive shaft. Emergency use at low energies.

LINING

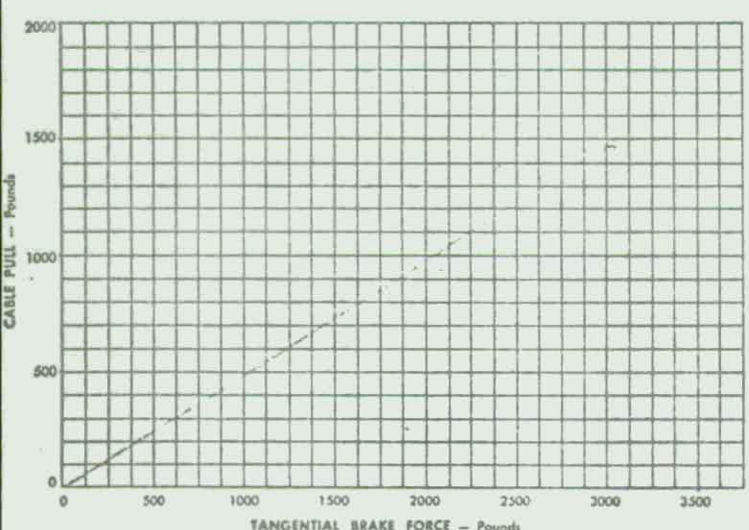
Organic, attached to lining carrier. Lining area 4 in.^{2}

DISK SIZE

6" to 20" diameter. Thickness 1/2".

DESCRIPTION

Pin-mounted lining carriers retained by pins. For use on all types of vehicles. Mounts ahead of reduction. Linkage adjustable for lining wear. Limit cable pull to 1500 lbs.



TORQUE FORMULA

Brake Radius = (.5 X Disk Dia.) – .62
Brake Torque = Tangential Brake Force X Brake Radius

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

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DATE 2-20-74 REPORT NO.

ATLAS CRANE

ATLAS WILL USE A MODIFIED BA-2 WORKHORSE CRANE BUILT BY AUTOCRANE COMPANY. BECAUSE OF SPACE LIMITATIONS THE COMPLETE UNIT CAN'T BE USED. THE HOIST WINCH IS REMOVED AND MOUNTED INSIDE THE VEHICLE. A SPECIAL BASE WITH MOUNTING FOR A HYDRAULIC CYLINDER IS ADDED SO THAT THE BOOM CAN BE RAISED BY A HYDRAULIC CYLINDER. THE STANDARD BOOM IS USED WITH A CLEVIS ADDED TO CONNECT THE HYDRAULIC CYLINDER. (THE AUTOCRANE HYDRAULIC HBA-2 IS ALSO TOO LARGE.) THE STANDARD 5'4" TO 9' TELESCOPING BOOM IS USED WITH THE LOAD SENSOR KIT ADDED. THE LOAD SENSOR SHUTS OFF THE HOIST WINCH IF TOO BIG A LOAD IS LIFTED.

THE HYDRAULIC CYLINDER IS SINGLE ACTING. DEPENDING ON THE METERING ABILITY OF THE CONTROL VALVE IT MAY BE NECESSARY TO ADD RESTRICTORS TO THE CYLINDER TO CONTROL RAISE & LOWER SPEED OF THE BOOM. IT MAY ALSO BE DESIROUS TO CONTROL THE HYDRAULIC CYLINDER WITH THE LOAD SENSOR.

THE BOOM CAPACITY WILL BE GREATER THAN LISTED BY THE MANUFACTURER, SINCE THE ADDITION OF THE HYDRAULIC CYLINDER REDUCES THE CANTILEVERED LENGTH OF THE BOOM.

PACIFIC CAR AND FOUNDRY COMPANY

ENGINEERING DEPARTMENT

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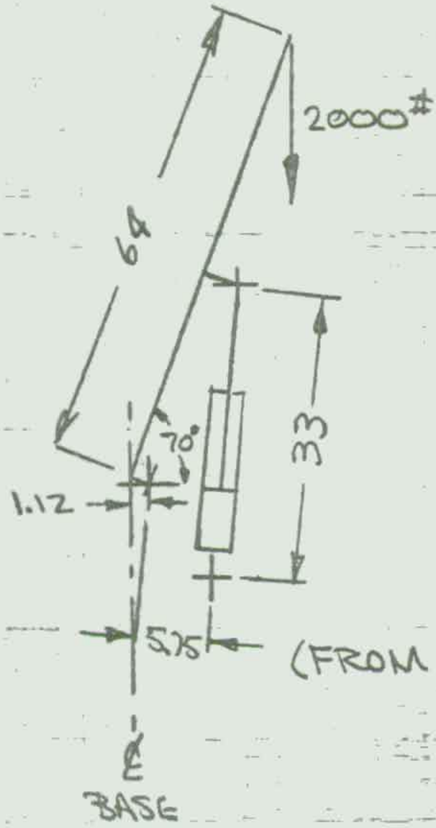
DATE 2-20-74 REPORT NO.

CRAME LOADS

MAX LOAD - 2000# @ 70° ELEV, 5'4" BOOM LENGTH



(FROM LAYOUT)

CYLINDER FORCE = $\frac{2000 \sin 70° (64)}{5.75}$

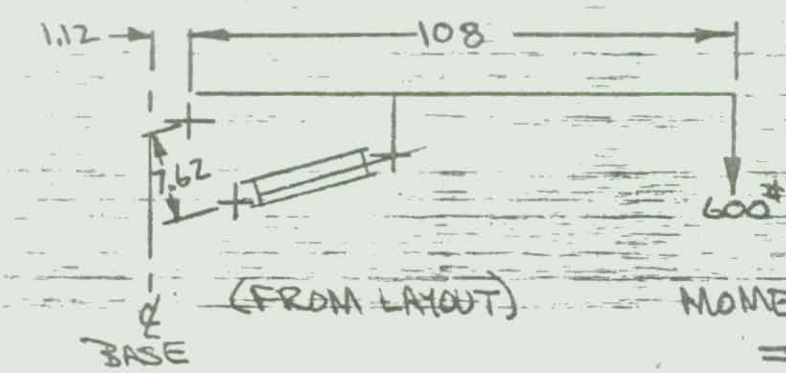
$= 7620\#$

MOMENT AROUND BASE ℄

$= 2000[(64 \sin 70°) + 1.12]$

$= 46,100$ LB-IN

MAX LOAD - 600# @ 0° ELEV, 9' BOOM LENGTH



CYL FORCE = $\frac{600(108)}{7.62}$

$= 8500\#$

MOMENT AROUND BASE ℄

$= 600(108 + 1.12)$

$= 65,500$ LB-IN

PACIFIC CAR AND FOUNDRY COMPANY
ENGINEERING DEPARTMENT

PREPARED BY H. G. Kirschner
CHECKED BY
DATE 2-20-74

ORDER NO.
PAGE 3 OF
REPORT NO.

CYLINDER SIZE

ASSUMING $\mu = .25$, TORQUE ON BOOM PIVOT PIN $\approx .31(8500^{\#}) = 2660$ LB-IN
(.625 DIA)

ADDED CYL FORCE REQ'D $= \frac{2660}{7.62} = 350^{\#}$

FOR 2.5 IN BORE CYL
PRESS REQ'D $= \frac{8850}{2.5^2(\pi/4)} = 1800$ psi

RELIEF VALVE SETTING IS 2000 psi ← OK

FROM LAYOUT
MAX EXTENDED LENGTH = 33 IN

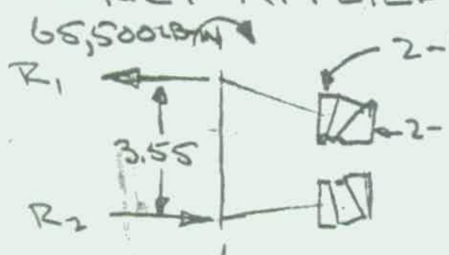
FOR BRUNING TYPE 3 DEZCTO CYL
MAX LENGTH = 8.88 + 2xSTROKE
(W/RE-1 ROD END)
STROKE $= \frac{33 - 8.88}{2} = 12.06$

USE 12.00 ←
(W/BOOM RESTING ON PROJECTILES MIN LENGTH IS 26.88, OR 6.12 STROKE SO CYL IS OK)

USE BRUNING CYL 3-2.5-12.00-RE1 ←

KINGPOST BEARINGS

AT HORIZONTAL POSITION MOMENT IS MAX AND IS ONLY APPLIED LOAD ~~(600# IS NEGLIGIBLE)~~



$R_1 = R_2$, NO THRUST
$\therefore R_{EQ} = R_1$ (TIMKEN ENG JOURNAL)

$R_1 = \frac{65{,}500}{3.55} = 18{,}450^{\#}$

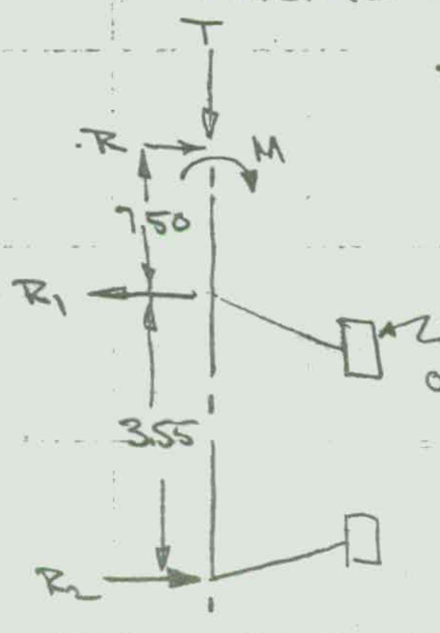
PCF-RN-597

FOR SLOWLY OSCILLATING BEARING
R_E CAN BE AS HIGH AS 4 x BRR
FOR THIS BEARING BRR = 6950#

$$\frac{R_E}{BRR} = \frac{18{,}450}{6950} = 2.66$$ ← (PLENTY OF CAPACITY)

AT 70° ELEVATION

MOMENT = 46,100 LB-IN
THRUST LOAD = 2000 (COS 70°) = 1880#
RADIAL LOAD = 2000 (SIN 20°) = 685#



$$R_1 = \frac{M + 11.05R}{3.55} = \frac{46100 + 11.05(685)}{3.55}$$
$$= 15{,}120\#$$

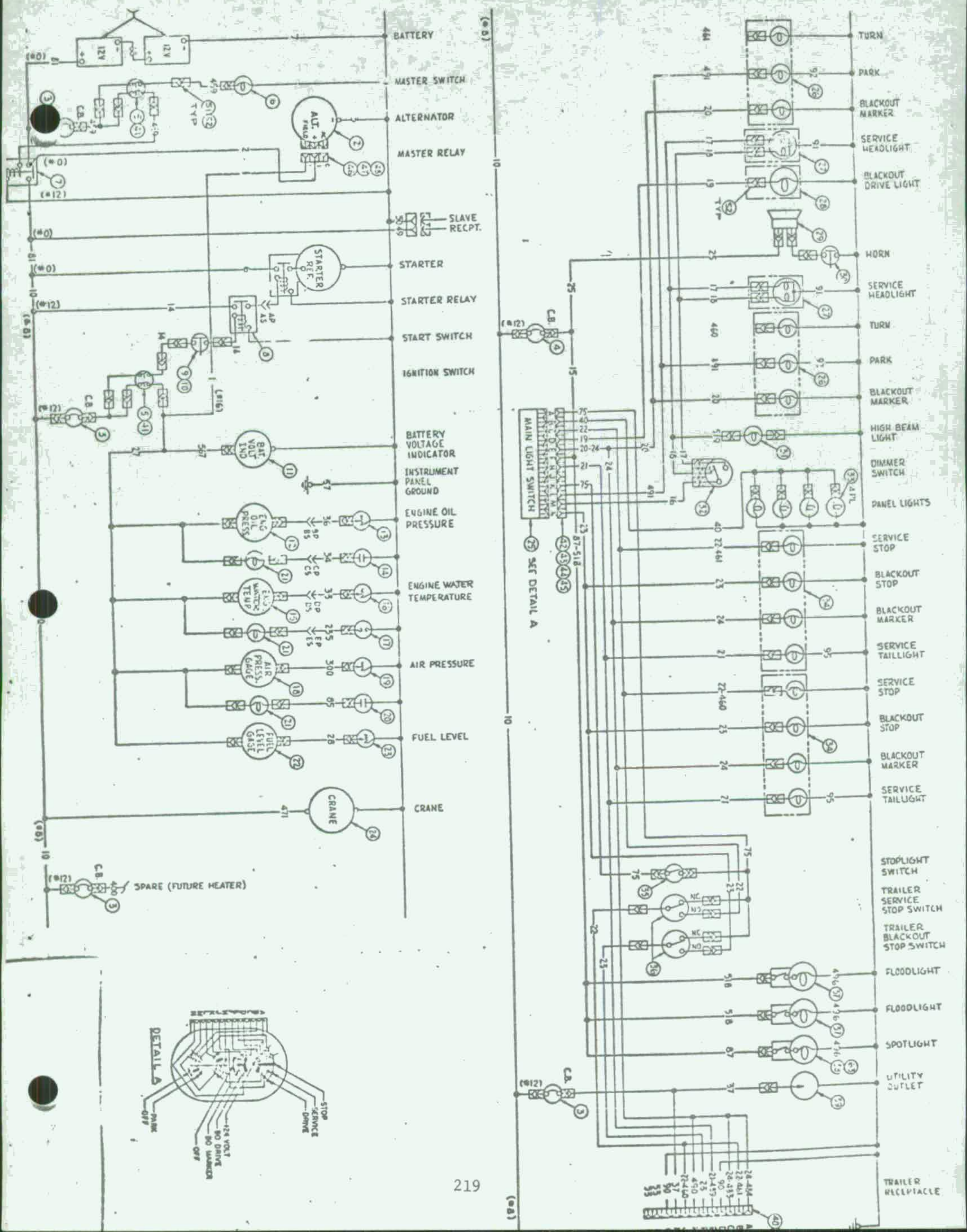
$$R_2 = R_1 - R = 14{,}430\#$$

ALL T ON THIS BRG

(FROM TIMKEN JOURNAL)
$$R_{E_1} = .53R_1 + .47R_2 + KT$$
$$= .53(15{,}120) + .47(14{,}430) + 1.55(1880)$$
$$= 17{,}620\#$$

$$R_{E_2} = R_2 = 14{,}430\#$$

$$R_{E_1}/BRR = \frac{17620}{6950} = 2.54$$ ← OK


BATTERY
MASTER SWITCH
ALTERNATOR
MASTER RELAY
SLAVE RECPT.
STARTER
STARTER RELAY
START SWITCH
IGNITION SWITCH
BATTERY VOLTAGE INDICATOR
INSTRUMENT PANEL GROUND
ENGINE OIL PRESSURE
ENGINE WATER TEMPERATURE
AIR PRESSURE
FUEL LEVEL
CRANE
SPARE (FUTURE HEATER)
DETAIL A
MAIN LIGHT SWITCH
SEE DETAIL A
TURN
PARK
BLACKOUT MARKER
SERVICE HEADLIGHT
BLACKOUT DRIVE LIGHT
HORN
HIGH BEAM LIGHT
DIMMER SWITCH
PANEL LIGHTS
SERVICE STOP
BLACKOUT STOP
SERVICE TAILLIGHT
STOPLIGHT SWITCH
TRAILER SERVICE STOP SWITCH
TRAILER BLACKOUT STOP SWITCH
FLOODLIGHT
SPOTLIGHT
UTILITY OUTLET
TRAILER RECEPTACLE
PARK
OFF
STOP
SERVICE
DRIVE
12V

ATLAS 1/31/77

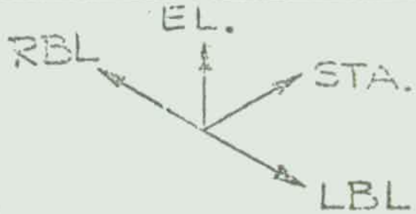
C. G.				MOMENTS		
Wt.	STA	EL	BL	M_{STA}	M_{EL}	M_{BL}
9446	103.9	44.2	4.8	981,585	417,778	45,269
4325	131.7	46.0	-5.6	569,441	199,106	-24,181
13,771	112.6	44.8	1.5	1,551,026	616,884	21,088

Powertrain & Engine Accessories

COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL / LBL	W(X)	W(Y)	W(RBL) / W(LBL)
Engine	1	1190	82.1	47	6	97,699	55,930	7140
Trans	1	240	56	40.75	6	13,440	9780	1440
Alternator	1	60	110	56	7	6600	3360	420
Air cleaner Abbot	1	23	89	84.5	-7.5	2047	1944	-173
Hose .2 lb/ft 4 inch hose	1	2	102	71	-19	204	142	-38

TOTAL 15.5 REF: & OF

Cooling System



EH:

COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	-RBL / +LBL	W(X)	W(Y)	W(RBL) / W(LBL)
Radiator 100 lb + 2 qts water = 50	1	150	90.2	55.5	6	13,530	8325	900
Shroud	1	25	95.5	53	6	2388	1325	150
Piping	1	5	105	53	6	525	265	30
Brackets	1	10	90	55	-6	900	550	60

Exhaust System

RBL / EL. / STA. / LBL — COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL / LBL	W(X)	W(Y)	W(RBL) / W(LBL)
Muffler Abbott	1	20	127	26	17	2540	520	340
Piping 90" (2.4 lb/ft.)		18	97	53	12	1746	954	216
Elbow 3×6 lbs 2×3.5 lb		25	97	53	12	2425	1325	300
Heat Shield	1	7	96	83	9.5	672	581	67

Fuel System

EH:

COMPONENT	QUAN.	WEIGHT W	STA. X	EL Y	RBL / LBL	W(X)	W(Y)	W(RBL) / W(LBL)
Fuel Tank	1	15	147	41	12.5	2205	615	188
Fuel 36 gal. ${}^{5.6=.8}$ diesel oil		240	147	41	12.5	35,280	9840	3000
HOSES		5	119	50	0	595	250	0

Suspension & Drive System from Trans.

EL. / RBL / STA. / LBL — EH: COMPONENT	QUAN.	WEIGHT W	STA. X	EL Y	RBL / LBL	W(X)	W(Y)	W(RBL) / W(LBL)
Front assy								
Shocks	2	30	90	23	0	2700	840	0
Torsion bars 47 x 2.5	2	131	76	27	0	9956	3537	0
- Suspension arms (Ends 4.5 qls) 23 x (5x.25 + 4x.38) = 221	4	103	84	24	0	9072	2592	0
- Panhard rods 5 px 2 (.13 wall)	1	12	88	19.3	0	1056	232	0
225 Torsion bar covers 20 x .25 x 47 Part of [illegible]	1	67	75	27	0	5025	1809	0
Brakes	2	84 2x39 162	100	21.5	0	16,200	3433	0
TORSION BAR ANCHORS	4	80 AVE 20 ea	76	26	0	6080	2080	0
Rear assy								
Spring	2	14	148	24.5	0	2072	343	0
Suspension arm 40 x 2.5 x .25	2	14	137	18	0	1918	252	0
Panhard rod 25 x 1.5 (.094 wa.)	1	5	139	17.5	0	695	88	0
Shocks	2	20	145	23.5	0	2900	470	0
Brakes	2	+2x23 = 176 60 + 30	145.5	15.4	0	21,243	2248	0
Tie rod 1x3 x .219 wall x 32	1	8	139.5	15.4	0	1116	120	0

REF: 6 OF

226

Suspension etc.

EH: EL. RBL STA. LBL — COMPONENT	QUAN.	WEIGHT W	STA. X	EL Y	RBL / LBL	W(X)	W(Y)	W(RBL) / W(LBL)
Steer axle 87 x 3 x 3 [illegible] (50 lbs) + 10	1	282	145.5	15.4	0	41,031	4343	0
Drive axle	1	.6 x 429 + 260 (517)	100	21.5	0	51,700	11,116	0
Differential	1	.4 x 429 (172)	98	21.5	7.5	16,856	3698	1290
Drive shaft 1 1/30 x 3.5 x .095 Abbot	1	78	132	26.5	8.63	10,296	2067	673
V-Joints See Abbot	2					[illegible]	5	
						[illegible]	3	
[illegible] & Thrust Washer						[illegible]	7.5	
						[illegible]	6	
Spacer		25				[illegible]	9	
Spring bracket		at susp. c.c.				Spindle [illegible]	6 + 12 [illegible]	
						[illegible]	9	
						[illegible]	4	
Front Tires [illegible]	2	wheels 180 + 2 x 180 (540)	100	21.5	0	54,000	11,610	0
Rear Tires [illegible]	2	wheels 84 + 2 x 70 (224)	145.5	15.4	0	32,592	3450	0

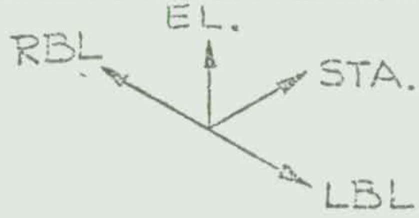
[illegible]

Air & Hydraulic

REBL / EL. / STA. / LBL FH: COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL / LBL	W(X)	W(Y)	W(RBL) / W(LBL)
Hydraulic Reservoir [illegible]		15 [illegible] (159)	147	39	-17.5	23,373	6201	-2783
Hydraulic Pump w/ Power Take off		8	140	23	12.5	1184	184	100
	1	30	143	26	12	4290	780	360
Hyd Pump (2)		8	135.5	46.8	9.8	1084	374	78
Hyd Filter	1	4.3	132.5	51	-16.3	570	219	-70
227 Alcohol injector	1	5	86	63	19	430	315	95
Water Ejector	1	2	101.3	38.5	19	203	77	38
Power cluster (Air/Hyd) (Master cylinder)	1	25	122	24.5	17	3050	613	425
Air compressor	1	55	105.5	47.5	-17	5803	2613	-935
Air reservoir	2	44	89.5	53.2	14	3938	2341	616
Valve Body	1	~50	125.5	34.25	17.5	6275	1713	875
Valves (2)	2	28	131.5	43	17	3682	1204	476
	1	14	117	47.3	15.5	1638	662	217
PIPING		10	125	57	0	1250	570	0
Rotary Actuator		350	123	89	0	43,050	31,150	0

REF: ¢ OF

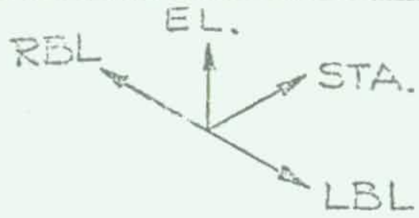
Air & Hyd.



COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL/LBL	W(X)	W(Y)	W(RBL)/W(LBL)
Driver		175	75.55	86.13	34	13,221	15,073	5950
Steering Wheel	1	4	58	71	34	232	284	136
Paint		15	Vehicle C.G.					
Seat, Driver		30	82.75	61.3	34	2483	1836	1020
TOTAL		224	REF.: ℄ OF			[illegible]	[illegible]	[illegible]

228

Frame



VEH.:

COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL / LBL	W(X)	W(Y)	W(RBL) / W(LBL)
Frame		965 + 400 1365	106.5	48	0	145,373	65,520	0

Side Panels

RBL / EL. / STA. / LBL

EH:

COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL/LBL	W(X)	W(Y)	W(RBL)/W(LBL)
(1) $\frac{33+16}{2}$ x 27 x .06		12	68	57	+ 23.5	816	684	282
(2) 37 x 33 x .06		21	73	64	48	1533	1344	1008
(3) 70 x 17 x .06		20	123	43	23.5	2460	860	470
(4) 23 x 25 x .06		10	54	60.5	34.5	540	605	345

230

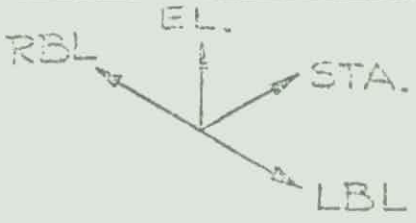
Electrical

RBL, EL., STA., LBL

E.H.:

COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL/LBL	W(X)	W(Y)	W(RBL)/W(LBL)
Batteries (Filled)	2	150	146	47.5	6	21,900	7125	900
Tray	1	25	146	42	-6	3650	1050	150
Head Lights (3/side)	6	12	51	83.5	0	612	1002	0
Other Lights	5	10	85.7	88	7.7	857	880	77
WIRING Fwd cowl		50	62	67	15	3100	3350	750

Controls



COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL / LBL	W(X)	W(Y)	W(RBL) / W(LBL)
Controls		100	107	41	16	10,700	4100	1600
TOTAL		[illegible]	REF.: ℄ OF			[illegible]	[illegible]	

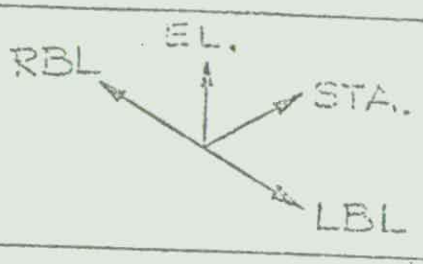
Misc.

COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL/LBL	W(X)	W(Y)	W(RBL)/W(LBL)
Winch Bu engine	1	200	107.5	49	17	21,500	9800	3400
Winch Front [illegible]	1 [illegible]	207	67	36	0	13,869	7452	0
CRANE (for [illegible])	1	200	130	56	36.75	26,000	7350	7350
Boom, Towing	1	522	141.5708	65.383	0	73,900	39,130	0
Roll Cage	1	198	65	98	32	12,870	19,404	6336
Front Powder Bin	1	80	44.2	65.4	0	3536	5232	0
CROSS BEAM Detail		180	106	78.25	0	19,080	14,085	0
[illegible] Detail		393	93	44	0	3[illegible],024	17,[illegible]	0

TOTAL [illegible] REF: ¢ OF [illegible]

Ammunition & Fuses

EH:



COMPONENT	QUAN.	WEIGHT W	STA. X	EL. Y	RBL / LBL	W(X)	W(Y)	W(RBL) / W(LBL)
[illegible]	30	1020	65.136	68.678	-9.985	66,439	70,052	-10,135
Shells	30	3105	156.683	37.376	-2.157	486,502	116,054	-6696
Fuses Lg. Box 40	64	200	82.5	65	-36.5	16,500	13,000	-7300
Small Box 20								
TOTAL		4225	REF.: ℄ CF			569,441	199,106	-24,181

234

P.C.F. SALES NO. ____ CONTRACT NO.

FILE NO. 8019 DRAWING SERIES 8019-XXX

DRAWN BY	DRAWING NO.	SIZE	SHT'S	TITLE	NEXT ASSY.
	1				
[illegible]	-3	R	1	DRIVE AXLE BRAKE LAYOUT	
[illegible]	-4	R	1	STEER AXLE BRAKE LAYOUT	
[illegible]	-5	R	1	STEER AXLE LAYOUT	
SB	-6	K	1	TRANSFER CASE LAYOUT (CONVERTED TO 8019-216)	
	-7	K	1	ROLL CAGE CONCEPT LAYOUT	
[illegible]	-8	K	1	SUSPENSION LAYOUT	
	-9				
[illegible]	-10	K	4	CLASS & DIV. - OVERALL VEHICLE LAYOUT	

[illegible] BY	[illegible] NO.	[illegible]	TITLE	NEXT ASSY.
	100	K	F[illegible] ASSY	
	101	K	S[illegible]	
	-102	D	SIDE FRAME, ARCH	
	-103	D	BEAM, ARCH	
	104	D	B[illegible] ASSY	
	-105			
RF	-106	C	K[illegible] PIN	
RF	107	B	PIN, DRIVE	
	-109	B	THRUST WASHER	
	-110	B	BUSHING, KINGPIN	
	-111	C	A[illegible] ROTA[illegible]	
	-112	K	B[illegible]TING CYLINDER AND ARCH	
	-113	B	STU[illegible] SHOCK MOUNTING	
	-114	D	TRUNNION ASSY	
	-115	B	BR[illegible], RADIATOR MOUNT	
	116	C	BRACKET, RADIATOR MOUNT	
	117	D	S[illegible] BRACKET [illegible]	
	118	C	BRACKET, SHOCK [illegible]	
	119	B	BOLT, FRAME	
	-120	C	MOUNT, FRONT ENGINE	
	121	C	BRACKET, PUMP [illegible]	
HK	-122	R	FRONT BOOM LATCH LAYOUT	
RF	-123	B	WASHER	
DM	-124	C	BRACKET	

DRAWN BY	DRAWING NO.	SIZE	SHT'S	TITLE
	-200	K		POWERTRAIN INST.
	201			TRANSFER CASE
	-204	D		RADIATOR
	-205	D		SHROUD, RADIATOR
	-206	B		SUPPORT, RADIATOR
	-207	B		SUPPORT, RADIATOR
	-208	C		ADAPTOR (OUTLET)
	209	C		TUBE (INLET)
	210	C		TUBE BYPASS
	-211	B		ANGLE (RADIATOR)
	-212	K		FUEL TANK ASSY
	-213	F		HOUSING, TRANSFER CASE
	-214	F		HOUSING TRANSFER CASE
	215	F		HOUSING ASSY (MACHINED)
	216	K	1	TRANSFER CASE ASSY
	217	D	1	SPLINE, ADAPTER
	218	C	1	NUT
	-219	D	1	FORK, SHIFT
	-220	D	1	SPLINE, FLOATING
	221	D	1	SHIFTER ASSY

FCF RN5251

DRAWN BY	DRAWING NO.	SIZE		TITLE	NEXT ASSY.
	222			GEAR INPUT, 43T	
	223			GEAR INPUT, 59T	
	224			GEAR IDLER	
	225	F	/	GEAR OUTPUT	
	226		/	SPACER	
	227		/	DISC	
	228	F	/	ADAPTER PLATE	
	229	C		CAP (BRG)	
	230	C		CAP (BRG)	
	231	D		BRACKET (PARKING BRAKE)	
	232	B		RING	

PCF [illegible]

FILE NO.

PROJECT DRAWING

DRAWN BY	DRAWING NO.	SIZE	SHT'S	TITLE	NEXT ASSY.
	-300			SUSPENSION	
	-301	D		DRIVE AXLE	
RF	-302	D		TORSION BAR	
RSH	-303	D		SUSPENSION ARM, DRIVE AXLE	
	-304	C		SUSPENSION ARM, STEER AXLE	
	-305	D		PANHARD ROD ASSY, DRIVE AXLE	
	-306	C		TORSION BAR ANCHOR, FRAME, DRIVE AXLE	
	-307	D		TORSION BAR ANCHOR, ARM, DRIVE AXLE	
RF	-308	B		BUSHING	
	-309	B		BUSHING	
	-310	B		WASHER, THRUST	
	-311			COVER, TORSION BAR	
	-312	B		SPACER	
	-313	D		STEER AXLE ASSY	
	-314			SPRING	
	-315	C		TIEROD	
	-316			PANHARD ROD ASSY, STEER AXLE	
	-317	B		PIN, SPRING BRACKET	
	-318			BRACKET, SPRING	
	-319	B		PAD, BUMP STOP	
	-320			SLEEVE	
	-321			WASHER	
DM	-322	B		SPACER	
DM	-323	B		PLUG	

FILE NO. 8019

PROJECT DRAWING

DRAWN BY	DRAWING NO.	SIZE	SHT'S	TITLE	NEXT ASSY.
WLG	-400	K	1	DRIVERS AREA LAYOUT	
WLG	-401	K	2	CONTROLS LAYOUT	

HYDRAULICS

P.C.F. SALES NO.

NO. 3602

FILE NO. 8019

PROJECT DRAWING

DRAWN BY	DRAWING NO.	SIZE	SHT'S	TITLE	NEXT ASSY.
Jac	-501	D	1	SCHEMATIC, HYDRAULIC SYSTEM	
Jac	-502	F	1	COMPONENT - LAYOUT AIR & HYD	
Jac	-503	F	1	RESERVOIR ASSY	

DRAWN BY	DRAWING NO.	SIZE	SHT'S	TITLE	NEXT ASSY.
[illegible]	-[illegible]	D		SCHEMATIC, AIR SYS.	
[illegible]	-[illegible]	[illegible]		DISC, BRAKE, DRIVE AXLE	
[illegible]	-60[illegible]	[illegible]		DISC, BRAKE STEER AXLE	

P.C.F. SALES NO. ______ CONTRACT NO 3602

PROJECT DRAWING

FILE NO. 3019

DRAWN BY	DRAWING NO.	SIZE	SHT'S	TITLE	NEXT ASSY.
FC	-701	F	2	SCHEMATIC, ELECTRICAL	

P.C.F. SALES NO. ______ CONTRACT NO. 3602

PROJECT DRAWING

FILE NO. 3019

DRAWN BY	DRAWING NO.	SIZE	SHT'S	TITLE	NEXT ASSY.
JAC	-800	K	1	CRANE & WINCH INSTL.	